DOCUMENT RESUME

ED 178 296 SE 028 642

AUTHOR	Lien, Violetta F.
TITLE	Investigating the Marine Environment and Its Resources, Part I.
INSTITUTION	Texas A and M Univ., College Station.
SPONS AGENCY	National Oceanic and Atmospheric Administration (DOC), Rockville, Md. National Sea Grant Program.
REPORT NO	TAMU-SG-79-401
PUB DATE	Jun 79
GRANT	NOAA-04-8-M-01-169
NOTE	349p.; For Part II, see SE 028 643
AVAILABLE FROM	Sea Grant Program, Texas A&M University, College Station, Texas 77843 (Parts I and II $8.00)
EDRS PRICE	MF01/PC14 Plus Postage.
DESCRIPTORS	Class Activities; *Ecology; *Environment; *Environmental Education; *Environmental Influences; Marine Biology; Natural Resources; Oceanology; *Science Education; *Water Resources
IDENTIFIERS	*Sea Grant

ABSTRACT

This is the first of two volumes comprising a resource unit designed to help students become more knowledgeable about the marine environment and its resources. Included in this volume are discussions of geography of the Gulf of Mexico, geology, physical characteristics of the marine environment, marine ecology, and ocean/land interaction. Discussions are intended to help students analyze their life-style and how it is influenced by the marine environment and their use of marine resources. (Author/RE)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED178296

SE

Investigating the Marine Environment and Its Resources

Part I

by Violetta Lien

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY
Amy Broussard

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

SE 029 642

Sea Grant College Program • Texas A&M University
TAMU-SG-79-401

INVESTIGATING THE MARINE ENVIRONMENT AND ITS RESOURCES

PART I

by

Violetta F. Lien

Department of Educational Curriculum and Instruction
Texas A&M University

illustrated by

Diane C. Mersenski
Nancy Pedulla
Jim Raatz
Jill Wiggins

TAMU-SG-79-401

June 1979

Reproduction of any part of this book, except for classroom instructional use, is prohibited without prior approval from the publishers, the Texas A&M University Sea Grant College Program
Copyright Pending
Partially supported through Institutional Grant 04-8-M01-169
to Texas A&M University
by the National Oceanic and Atmospheric
Administration's Office of Sea Grant
Department of Commerce

Acknowledgments

A special word of appreciation to Dr. Delmar Janke, Project Leader who developed the proposal, provided guidance and encouragement.

I wish to acknowledge the cooperation of the following teachers who field-tested the various activities, contributed suggestions and whose enthusiasm made this project possible:

Wm. L. Barclay
Jan Blankenship
Don Bussey
Kirk Carter
April Faulkner
L. W. Frederiksen
Elaine Hazelton
Homa S. Hill, Jr.
Bryant A. Honey, Jr.
Mary Jennings
Kathy A. Krnavek
Paul Lessard
Georgia Lillian
Patricia Moore
Jeffrey Schwarz
Beverly K. Shideler
Mary Spruill
Ruth Sullivan
Diana Virva
Sandra West
John Wilkinson

A thank you is also extended to the following: Ralph W. Lien for understanding, encouragement, technical assistance, and photography; Pat Sadberry for encouragement, compiling the tapes, and technical assistance throughout the unit; Laurel A. Keese and Janet Kriv for assisting with the manuscript preparation; Texas A&M Department of Educational Curriculum and Instruction office staff for their encouragement and assistance for the entire project; Texas A&M Sea Grant Office for technical assistance, supplemental slides and references; and Texas A&M Geography Department Cartographic unit for the maps.

A special note of acknowledgment for typing the first manuscript to Renai Baker and to Gwen Bray, Beth Van Cleave, and Diana Van Cleave for typing the revised manuscript.

Sherrill Norris deserves a special note of acknowledgment for reading and commenting on the original unit.

$8 (Parts I and II)

Additional copies of this publication
may be ordered from:

Marine Information Service
Sea Grant College Program
Texas A&M University
College Station, TX 77843

TABLE OF CONTENTS

PART I PAGES

I. UNIT OVERVIEW

Major Goals and Objectives 3

II. TOPIC ONE--INTRODUCTION 5

Activity One--Earth Is a Water Planet 9
- A Syntu About the Sea 11
- The Sea and Me 12
- Brainstorm--How Water Influences Us 13
- Slides/Cassette Tape--Earth is a Water Planet 14
- Collage of Concerns and Feelings 19

Activity Two--Words, Poems and Books of the Sea. 20
- Words from the Sea. 21
- Sea Language Ashore 23
- Marine Words 28
- Poetry of the Sea 29
- Letters of the Sea 30
- Books of the Sea 32
- Tales of the Sea 34
- Tale of the Sea 35

Activity Three-Signals of the Sea 36
- Signal Flags. 37
- Signal Flags and Communication 39

III. TOPIC TWO--THE SHAPE OF IT! 40

Activity One--Trip Into the Depths of the Gulf 43
- Trip into the Depths of the Gulf of Mexico 45
- Characteristics of the Floor of the Gulf 53

Activity Two--The Ocean Floor 54
- Topography of the Ocean Floor 56
- Mural of the Ocean Floor 58
- Exploring Terra 59

IV. TOPIC THREE--GEOLOGY OF THE GULF 61

Activity One--Drifting Continents and Prehistoric Organisms 64
- Marine Geology 65
- Continental Puzzle 67
- The Puzzle. 69
- Plate Tectonics or Sea-Floor Spreading 70
- Prehistoric Marine Organisms 77

Activity Two--Texas Gulf Coast--Geological Past 80
    Where was the Texas Coast In the Past? 89
    Texas Gulf Coast-Pleistocene to Recent 91
    A Geological Detective Story 92
    Geology of the Gulf of Mexico 93

Activity Three--Texas Gulf Coast--Recent 95
    Features of the Gulf Coast 96
    Changing Coastlines in Historic Times 100
    Trouble in Paradise 104

V. TOPIC FOUR--THE PHYSICAL CHARACTERISTICS OF THE OCEAN 105

Activity One--The Smell and Taste of the Sea 109
    Smell 110
    Taste 111

Activity Two--The Noisy Deep (Sounds of the Gulf) 112
    The Sounds of the Gulf 113
    Cassette Tape/The Noisy Deep 113
    Monsters of the Deep 114
    Voices of the Noisy Deep 118
    Sound in the Sea 120

Activity Three--The Light and Dark of It 121
    The Light and Dark of It 122
    Light in the Sea 125

Activity Four--The Hot and Cold of It 127
    Temperature of the Water 129
    Sea Ice Formation 130
    The Frozen Seas 131

Activity Five--A Little Salt and Force 132
    What is the Salinity? 133
    A Little Salt 134
    Why is the Ocean Salty? 136
    The Force--Pressure 138
    Sea Water and Pressure 141

Activity Six--Density and the Sea 142
    Salinity and Density 143
    Temperature and Density 144
    Sea Water and Density 146

Activity Seven--It Moves! 147
    Currents 149
    Surface Currents of the Gulf of Mexico 154
    How Tides are Formed 157
    In and Out--The Tides 158
    Waves 160
    Make Waves 162
    Catastrophic Waves 164
    Say It with a Dance 165

VI. TOPIC FIVE--SEA INTERACTS WITH THE LAND 166

Activity One--Texas Coastal Climatic Zones 171
  The Gulf of Mexico Interacts With the Texas Coast . . 172
  El Nino 176

Activity Two--Tropical Storms and Hurricanes 177
  Hurricane! 178
  Spectacular Agent of Change 180
  Hazardous Sea Warnings 182
  Hurricane Tracking 184
  Hurricane Flooding 185
  Hurricane Storm Surge 188
  How Would You Prepare for a Hurricane?. 189
  Hurricane Safety Checklists 189

VII. TOPIC SIX--THE MARINE ENVIRONMENT AND MARINE ECOSYSTEMS. . 194

Activity One--Zones of the Marine Environment. 199
  Zones of the Marine Environment 200
  Marine Zones and Abiotic Characteristics 204

Activity Two--Basic Groups of Marine Organisms 206
  Nekton 207
  Plankton 208
  Benthos 210

Activity Three--Intertidal Ecosystems 213
  Marine Ecosystems 221
  Rock, Jetties, and Groins 222
  Sandy Beach 223
  The Oyster Reef 224
  Salt Marshes 225
  Mud Flats 227
  The Water, Itself 228

Activity Four--Marine Organisms--Let's Get Acquainted. . . 229
  Underwater Life Activity (Fingerpainting) 231
  Syntu About a Marine Organism 232
  Marine Life Along the Coast of the United States . . 233
  Let's Get Acquainted 234
  Name the Animal 235
  Specially Designed 236
  Design a Beak 237
  Gyotaku: Preserve it with a Print 238
  Marine Mobiles 239
  *Eat Your Dissection (Teacher Section)

VIII. TOPIC SEVEN--EVERYONE BELONGS (ENERGY RELATIONSHIPS). . . . 240

Activity One--Producer, Consumer 244
  Producers, Consumers, Decomposers 245
  Marine Organism Card Deck 246

Activity Two--Who's for Dinner? 259
    Who's for Dinner? (Game) 260

Activity Three--Who-Eats-Whom 262
    Who Eats Whom (Card Game) 264
    Food Chain--Chains of Marine Ecosystems 266
    *Food Chain Mobiles (Teacher Section)

Activity Four--Can Life Exist Without Light? 267
    Can Life Exist Without Light? 268

Activity Five--The Big Web 269
    Food Webs of Marine Ecosystems 269
    What Would Happen If... ? 270
    The Uninvited Guest 271
    Food Web Tag (Teacher Section)

Activity Six--It's A Pyramid 272
    It's a Pyramid 273
    Make a Dolphin (Game) 274
    Food Pyramid Questions. 278
    Managing a Small Bay Area 279

IX. TOPIC EIGHT--THE BIG CIRCLE (CYCLES) 281

Activity One--The Big Circle (Cycles). 283
    Water Cycle 284
    Travels Through King Neptune's Domain 286
    Water Resources 287
    Water Cycle Questions 288

Activity Two--The Carbon-Oxygen Cycle 289
    Carbon-Oxygen Cycle 290
    Man and the Carbon Oxygen Cycle 292
    Questions on Carbon-Oxygen Cycle 293

Activity Three--The Nitrogen Cycle 294
    The Nitrogen Cycle. 295
    A Nitrogen Crisis 296
    Nitrogen Cycle Questions 298

Activity Four--The Not So Perfect Cycle 299
    The Not So Perfect Cycle (Phosphorous Cycle) 300
    Phosphorous Cycle Questions 302

X. TOPIC NINE--SUM IT UP! 303

Activity One--Man and the Marine Environment 305
    What Do You Say? 306
    Sapceship Earth 307
    I Am Only One 308
    Mercury in Lanaca Bay 309
    "Super-Preservative" for Sale?? 310
    It's Your Decision. 311

- Activity Two--Plan for the Future 312
    - Mariculture System for the Future 313
    - P.S. Activity 314

PART II

XI. TOPIC TEN--CHANGES 315

- Activity One--Change Is a Natural 317
    - Introduction to Change 318
    - It's Natural to Change 320
    - Once There Was One, Now There Are Two! 321

- Activity Two--Changes in Man's Activites and the Coastal Zone 325
    - 10,000 B.C. 326
    - 4,000 B.C. to 1,000 A.D. 326
    - 1520 A.D. to 1800 A.D. 327
    - 1800 to 1900 327
    - 20th Century 328
    - The Future 329

XII. TOPIC ELEVEN--WANTS OR NEEDS? 335

- Activity One--Wishes, Wants and/or Needs 337
    - A Dozen Wishes 338
    - Hierarchy of Human Needs 339
    - Show and Tell 340
    - Advertizing--Wants and Needs 341

- Activity Two--Past, Present and Future Needs 342
    - Karankawa--The Past 344
    - Early Texas Seaport 347
    - The Year 2000 350
    - My World 352

- Activity Three--Culture and Wants or Needs 353
    - Characteristics of Culture 354
    - Comparison of Cultures--Past, Present 355
    - My Imaginary Culture of the Future 356

XIII. TOPIC TWELVE--INTRODUCTION TO MARINE RESOURCES 357

- Activity One--What Is a Resource? 359
    - Renewable and Non-Renewable Resources 360

- Activity Two--Marine Resources 361
    - Marine Resources Introduction 362
    - Brainstorm--List the Marine Resources 362
    - Filmstrip/Cassette Tape--Marine Resources 363

Activity Three--How Do They Rate? 370
How Do They Rate?. 371
What Do You Think? 372

XIV. TOPIC THIRTEEN--LIVING MARINE RESOURCES 373

Activity One--A Sea Food Connoisseur. 380
Are You A Sea Food Connoisseur? 381
A Diner's Delight? 382
Sea Food Fair Taster Report. 383

Activity Two--Food From the Sea 384
It's Good for You! 385
Have You Eaten Algae This Week?. 386
Nutrition of Fish and Shellfish. 387
Fish Hot Dogs, Fish Bologna and Fish Jerky Anyone? . . . 388
FPC. 389
Fish As Animal Feed. 389
Supermarket Seafood Survey 391
Restaurant Seafood Survey. 392
Health Food or Oriental Food Store Survey. 393

Activity Three--Where Would We be Without Algae?. 394
Those All Important Sea Weeds. 395
Read the Labels. 396

Activity Four--Fishing. 397
Fishing in the Past. 398
Fishing Today. 399
Texas Fisheries. 400
Where Have All the Fish Gone?. 401
Fishing Laws and Regulations Simulation. 402

Activity Five--The Future 404
Housing Shortage 405
A Blue Revolution? 406
The Future--Scenarios A and B. 407
Make Buttons 410

XV. TOPIC FOURTEEN--TRANSPORTATION. 411

Activity One--Transportation--Early 414
Your Answer. 415
Transportation As a Resource 416
Transportation in the Past 417

Activity Two--Sea Chanteys and the Sailing Ships. 418
Cassette Tape/Sea Chanteys 420

Activity Three--Shipping Today 424
- The Superships 426
- Tugs, Barges and the Gulf's Waterway 429
- My Opinion 433

Activity Four--Texas Ports--Past and Present 434
- Indianola 435
- Galveston-1900 436
- Houston-1900 437
- Texas Ports Today 438
- Locate and Answer 442

Activity Five--Superports and the Future 444
- Prospect for a Superport 445
- The Future 448
- Texas' Future Water Highways 449

XVI. TOPIC FIFTEEN--MARINE ENERGY RESOURCES 450

Activity One--Oil! 454
- My Energy Position 456
- Here and Now with Energy 457
- Oil Production 461
- The Search for Oil 463
- Drilling for Oil 463
- Drilling for Production 464
- Getting Oil Ashore 465
- Undersea Platform 465
- Letter From an Offshore Oil Platform 466
- Environmental Impact of Offshore Drilling 467
- Oil Spill Simulation 469
- Pre-Oil Social and Environmental Impact 470
- Point/Counterpoint 472

Activity Two--Pollution Free Energy 473
- Pollution Free Energy 474
- Harvest of the Wind 474
- Sea Thermal Power 475
- Tidal Power 476
- Wave Energy 476
- Windmills in the Water 477
- Hydrogen to Burn 477
- Energy From the Earth's Depths 478
- Energy of the Future 479
- Ocean as a Coolant 479
- Design a Model or Display (Teachers Guide) Future Energy Headlines 481

XVII. TOPIC SIXTEEN--RICHES OF DAVY JONES' LOCKER 482

Activity One--Marine Mineral Resources . . . . . 48[illegible]
- Concentration of Elements in Sea Water 485
- Riches of Davy Jones' Locker 486
- Water--The Most Priceless Resource 487
- A Solar Still 488

More Riches of Davy Locker 489
Number Three Magnesium Metal 489
Oil--Black Gold 489
Natural Gas 490
Ocean Coal Mines? 490
The Economic Indicator 490
That's Gold in Them Waters 491
A Woman's Best Friend 491
Jewels From the Sea 491
The Dullest Resources--Sand and Gravel 492
The Mysterious Managanese Cobblestones 493
Shells and Sand 494
To Sum It Up 494
Who Is the Owner? 495
Questions of Ownership 496
What I Think Should Be Done 497

XVIII. TOPIC SEVENTEEN--RECREATION 498

Activity One--Marine Recreation and You 500
You Are the Recreation Director 501
Recreational Activities 502
Your Uncareer 503

Activity Two--A Needed and Beneficial Resource 504
Recreation--A Needed Resource 505
Recreation and the Economy 507
Problems in Recreational Development 508
Your T.V. Spot 508

Activity Three--Marine Parks? 509
Marine Parks 510
Design a Marine Park 511

IXX. TOPIC EIGHTEEN--WATERFOWL 512

Activity One--For the Birds 513
Waterfowl 514

XX. TOPIC NINETEEN--MARINE MEDICINE CHEST 517

Activity One--Marine Medicine Chest 518
Marine Medicine Chest--A Lifesaving Gold Mine 519
Marine Biomedicine 522

XXI. TOPIC TWENTY--THE UNSUNG HEROES . . . 525

- Activity One--Beauty . . . 527
  - Life's Extras . . . 528
  - A Refreshing Refill . . . 529
  - Jonathan Livingston Seagull Experience . . . 530
- Activity Two--Knowledge . . . 531
  - The Sea--A Source of Knowledge . . . 532
  - Evidence is Being Destroyed . . . 534
  - My Thoughts . . . 535
- Activity Three--Space . . . 536
  - Space--A Resource Too! . . . 539
  - Living and Working Under the Sea . . . 542

XXII. TOPIC TWENTY-ONE--RAP UP! . . . 544

- Activity One--Simulation: Shoreview . . . 546
  - Coastal Management Program Report . . . 547
  - Shoreview City Council Action . . . 551
  - Instructions for Simulation Shoreview . . . 553
  - Role Cards . . . 554
  - Information Sheets . . . 559
  - Questions . . . 560
- Activity Two--International Sea Exposition . . . 561
  - International Sea Exposition . . . 562
- Activity Three--My Feelings About It All! . . . 563
  - Say It with Music . . . 564
  - Self Contract . . . 565

XXIII. APPENDIX

ILLUSTRATIONS

PART I

Capt. Al G. Seaborne 10
International Flags and Pennants 38
Physiographic Provinces of the Gulf of Mexico 44
Gomeur (Minisub) 45
Continental Shelf 49
Continental Slope 50
View from Abyssal Plain to Continental Slope 51
Cross Section of Gulf of Mexico 52
Features of the Ocean Floor 55
Five Continental Pieces 67
Cretaceous Sea Floor and Permian Reef 72
Mesozoic Era and Jurassic Period 73
Prehistoric Marine Organisms 74
Texas Fossils--Swimming Dinosaurs 75
Texas Fossils--Fish 76
Maps of Texas Coast ....
  Lower Cretaceous 81
  Upper Cretaceous 82
  Lower Eocene 83
  Middle Eocene 84
  Miocene 85
  Pleistocene 86
  Today 87
  Geologic Map of Texas 88
Salt Domes of the Gulf Coast 94
Types of Coasts of Gulf of Mexico 98
Mississippi River Delta 101
Colorado River Delta 102
Matagorda Peninsula (Before and After Hurricane Carla) 103
Sea Monsters 116-117
Light Penetration 124
Temperature of the Depths 128
Map of Texas Coast (Bays) 135
Main Ocean Currents 153
Surface Currents of Gulf of Mexico--February-August 155
Tides 156
Terrain and Climatic Interactions of the Gulf 174
Hazardous Sea Warnings 182
Hurricane Tracking Map 184
Hurricane Flooding--Galveston Area 187
Zones of the Marine Environment 201
Diagram of Nutrients and Salts 202
Diagram of Dissolved Oxygen 203
Nekton 207
Plankton 209
Benthos 210
Plankton, Nekton, Benthos--Location 211
Profile of Intertidal Ecosystems 214

The Rocky Shore 215
Sandy Beach 216
Oyster Reef 217
Salt Marsh 218
Mud Flat 219
Open Water--Continental Shelf 220
Marine Organism Card Deck 246-258
Make A Dolphin (Game) 275-277
Food Pyramid of Bay 280
Water Cycle 285
Carbon/Oxygen Cycle 291
Nitrogen Cycle 297
Phosphorous Cycle 301

PART II

Sequential Changes in Matagorda Delta 322-323

Matagorda Bay

  Paleo-American Period and Neo-American Period 331
  Colonial Period and Nineteenth Century 332
  Modern Period and Future 333
Hierarchy of Human Needs 339
Karankawa Indian 343
Early Texas Seaport 346
Sailing Ship 419
Supership 425
Waterways of the United States 428
Trend in Barge And Tow Sizes 431
Modal Distribution of Goods Shipped From the Texas Coastal Zone 441
Future Ports 446-447
Exploration Rigs 458
Offshore Platform 459
Gulf Coasts Gas and Oil Deposits 460
Floating City of the Future 537
Man-made Island 538
Working Under The Sea and Homo Aquaticus 540
Future Under Sea City 541
Shoreview--Aerial View 550

INVESTIGATING THE MARINE ENVIRONMENT AND ITS RESOURCES

This resource unit provides activities to help students become more knowledgeable about the marine environment and its resources. They will learn about the intricate interrelationships (biological, physical, chemical) within the marine environment, and will consider man's past, present and possible future interaction with that environment and its resources. They will analyze their lifestyle and how it is influenced by the marine environment and their use of marine resources.

It is hoped that students will become aware of the things they must consider to live, as much as possible, in harmony with nature. As they understand how their lifestyle depends on the marine environment and its resources, they may learn to consider more carefully their treatment of that environment.

Our lives and fortunes depend on the water of the global sea and the fresh water of the land. This has always been true. We have based our progress and expansion on the false assumption that the bounty of land and water are endless, however, and that the rivers, estuaries and seas could absorb an infinite amount of wastes without harm. Now a combination of growth, demand and pollution is pushing us toward our fresh water limits and the depletion of some land resources has forced us to turn again to the seas. The population increase and the movement of people toward our saltwater shores place enormous pressures on the fragile coastal zones and adjacent waters while growing industrial use creates further pressure and occasional conflict. A reawakening to the importance of our marine waters is late, but not too late if we understand and support careful, planned use of our oceanic resources.

We would hope to do more than just make students aware that something must be done. We hope they will develop a basic understanding of the marine components' importance to American life and society and as a part of the whole environment. We hope to create an awareness of and sense of responsibility for water--to develop a "water ethic" embracing the proper uses, protection and conservation of the oceans and the coastal zone. We want to motivate students to take part in decision affecting the sea while equipping them with principles and information necessary to evaluate problems, opportunities and events. Achieving this will result in their becoming more "literate" in marine affairs. Athelstan Spilhaus, father of the Sea Grant concept, summarized the seas' potential:

> The oceans will offer us military, recreational, economic, artistic and intellectual outlets of unlimited scope. Thus they'll offer us more space itself in which to remain human. The sea--beautiful and dangerous, elegant and strong, bountiful and whimsical--not only challenges us but offers to every 'man in the street' the exciting participation of being a 'man in the sea.'

The unit is designed primarily for secondary school students in science (biology, earth science, ecology, life science, marine science, oceanography) and social studies, but it includes activities from many areas (e.g., social studies, science, history, reading/language arts, economics, music, art, sociology, home economics, consumer education, etc.). If a teacher shares this resource unit with those in other subject areas, all will have marine examples specifically for them and the combined programs will help develop an overall marine literacy.

Being a resource unit, this document contains many more activities than a teacher would include in a teaching unit related to marine resources. It is the responsibility of the teacher to determine the objectives of her/his unit and to select those activities most applicable to those objectives. The design is such that activities can be incorporated into existing courses, teachers can select activities to form a unit, or a complete course can be developed. A teacher can select one activity or all the activities in, for example, Topic One, Activity Two.

The drawings and student activities are easily removable to make transparencies or ditto or stencil masters. This allows the teacher to provide a classroom set or individual student copies. The unit contains a variety of activities for both the "traditional" and "non-traditional" teacher. The activities include games, simulations, role-playing, sea chanteys, poetry, art, interviews, skits, readings and values clarification.

The unit includes a statement of purpose, goals and major objectives, a set of specific learning outcomes for each topic, a teacher's guide and a collection of teaching/learning activities grouped in topic clusters. The goals and objectives for each topic are coded to correspond to the goals and major objectives for the unit. If a specific objective for a topic is coded 2.3, for example, it is part of general goal 2, objective 3.

From the perspective of the moon, the identification is clear: EARTH IS A WATER PLANET. Most education is very land-oriented. The overall purpose of this unit is to develop an interest in and awareness of the marine environment.

GOALS AND MAJOR OBJECTIVES FOR THE UNIT

GOAL 1: TO DEVELOP AN UNDERSTANDING OF THE INTRICATE INTERRELATIONSHIPS WITHIN AND AMONG ALL PARTS OF THE TOTAL ENVIRONMENT WITH EMPHASIS ON THE MARINE ENVIRONMENT AND RESOURCES.

1. Understand basic marine and environmental terms.
2. Recognize that in spite of great diversity in types of actual ecosystems there are certain general structural and functional attributes and the ecological relationships do not exist in a vacuum but in a physical-chemical setting.
3. Understand that ecological relationships are basically energy and nutrient relationships with sunlight as the basic source --usable energy decreases as we progress through the food chain or web while the amounts of nutrients are not diminished.
4. Conclude that all living things came originally from nonliving material and also that the elements of which living things are made are basically the same as those of nonliving materials and these elements move in cycles and are recycled.
5. Recognize that the abundance of water makes the earth unique in our solar system and that the oceans interact with the earth and its atmosphere.

GOAL 2: TO ANALYZE THE EFFECTS OF MAN'S PAST ACTIVITIES UPON THE MARINE ENVIRONMENT AND RESOURCES AND ANALYZE POSSIBLE FUTURE RESPONSES OF MAN'S INTERACTION WITH THE MARINE ENVIRONMENT AND RESOURCES AND CONSIDER HOW TO FORESEE AND AVOID UNDESIRABLE CONSEQUENCES.

1. Comprehend that man can and does affect the process of energy flow and nutrient cycling.
2. Conclude that the environment of any locality will change with the passage of time.
3. Recognize that environmental problems do not have simple answers; that problems have existed, exist, and will exist and many factors must be considered (e.g., ecological, social, economic, governmental, psychological, and moral).
4. Evaluate the needs and wants of organisms and man in an environment and recognize that the needs and wants change.
5. Recognize marine resources and the consumer products in terms of their resource origins.

6. Understand that resource use is determined by the needs and values of individuals and groups which may change with time and are influenced by cultural, social, economic and political factors.

7. Recognize the important influence which the marine environment has had and will continue to have upon the lives of people and upon the destiny of nations.

GOAL 3: BECOME MORE SKILLFUL WITH REGARD TO THE TECHNIQUES OF GOOD MANAGEMENT, PLANNING, AND PROBLEM SOLVING WITH RESPECT TO THE MARINE ENVIRONMENT AND RESOURCES NOW AND IN THE FUTURE.

1. Recognize that the quality of the marine environment will be in part a reflection of man's capacity to manage it; that problems have existed, exist and will exist and that it will require much more understanding of many factors (e.g., ecological, social, economic, governmental, psychological. and moral).

2. Analyze the role of technology in the use of resources--past, present, and future.

3. Analyze what considerations are important in the processes of acquisition of marine resources.

4. Understand the importance of future planning of the use of marine resources.

GOAL 3: DEVELOP A GREATER APPRECIATION OF THE MARINE ENVIRONMENT AND RESOURCES

1. Comprehend that man's perception of the marine environment may be either positive or negative depending on social, economic, or other factors.

2. Choose to interact with the environment in non-consumptive manners.

3. Become aware of man's relationship with the marine environment and resources.

TOPIC ONE--INTRODUCTION

ACTIVITY ONE--Earth is a Water Planet
ACTIVITY TWO--Words, Poems and Books of the Sea
ACTIVITY THREE--Signals of the Sea

Materials for Classroom Use:

- Captain Al G. Seaborne/sketch
- A Syntu About the Sea
- The Sea and Me/information sheet
- Brainstorm/information sheet
- Filmstrip cassette tape/"Earth is a Water Planet"
- Collage of Concerns and Feelings/activity
- Words from the Sea/activity
- Marine Words/reading
- Poetry of the Sea/information sheet
- Letters of the Sea/reading
- Tales of the Sea/reading
- Books of the Sea/activity
- Tales of the Sea/activity
- Signal Flags/reading
- International Signal Flags and Pennants/reference sheet
- Signal Flag and Communications/activities
- Magazines
- Newspapers
- Glue, scissors
- Coloring and writing materials
- Posterboard, newsprint or construction paper

Major Objectives for the Topic:

After completing the activities the student will be able to:

1.1 list and define new terms;
1.1 define and describe a marine environment;
1.5 conclude that planet earth is unique due to the abundance of water;
1.5 discuss the unique physical and chemical properties of water;
2.5 point out some marine resources;
2.7 conclude that Texas is a marine state;
2.7 identify ways the sea (marine environment) has influenced man and his heritage;
3.1 discuss man's use and management of the marine environment;
4.1 evaluate his feelings and concerns about the marine environment;
4.1 attempt to express his concerns about the marine environment;
4.1 share his feelings about the sea with his clasmates;
4.1 analyze poems and books of the sea;
4.1 discuss and demonstrate marine communications.

Teaching Suggestions:

The purpose of this activity is to introduce marine education and the topics of the unit to the students. The students will also evaluate their feelings about the marine environment. A slide/audio tape series having "Captain Al G. Seaborn" as the main character will introduce the concept of "Earth as a Water Planet." Students will be introduced to marine oriented books--literature and informational and marine communications. Select the activities which meet your students needs and the objectives of your course.

1. Make some introductory statements about the unit if you have not already done so at a previous time. Introduce Captain Al G. Seaborne who will be the personality that appears throughout the unit.

2. Have the students write a syntu. A syntu is a very simple form of Japanese poetry consisting of five lines which do not have to rhyme. Instead of giving the class an example, have the class write one or two together so they understand the instructions. Then have each student write their own. An example of one is given below:

Crab
It pinches
It is funny and scary
It tastes good
Cancer

The above is only one. There could be many variations of each line. Line five for an example could have been Sea food, Crustacean, Arthropod, Animal, etc.

This syntu is an excellent way to have the students make observations and descriptions briefly and quickly. Comparing lines 2, 3, and 4 of different syntus, one could probably identify what line one or five is. Have the students share and discuss their syntus with the class. If you are not a literature teacher you may want to share your students' syntus with the literature teachers.

3. If your students really enjoy writing syntus, you may encourage them to write a haiku. Haiku is also an ancient Japanese verse form. There are only seventeen syllables in the haiku; the first and third lines contain five syllables, the second line, seven. Almost every haiku may be divided into two parts; first, a simple picture-making description that usually includes some reference, direct or indirect to the season, the second, a statement of mood or feeling. A relationship between these two parts is implied, either showing a similarity or a telling difference. Two great haiku writers are Basho and Harry Behn. Your literature teacher(s) may help you.

4. Have the students complete The Sea and Me activity. You may find that your students' concept of priceless and worthless is in the

context of dollars. The context here is intended to be of a value beyond prices. This activity is intended to get the students to individually think of the sea and their concept of it.

5. Brainstorming can be done as a whole class or in small groups. It seems to work best in groups of 5-7. If you use small groups plan for a report to the class and the compiling of a class list.

6. Show the filmstrip/cassette tape "Earth is a Water Planet." Time: aprox. 15 minutes. It is intended to be a quick presentation of many ideas for later discussion and more detailed investigation. It is an overview.

7. You may have the students do Collage of Concerns and Feelings individually, in small groups or as a class. Lower level students can be a success in this activity too.

8. Have the students complete the Words from the Sea activity. Encourage them to use the library and dictionaries (large) to find other words. Harold L. Goodwin is in the process of compiling a book on words of marine origin and the story or history of the word's usage. You may want to check the library's Books in Print periodically to determine when it is available.

9. Have the students read Marine Words and make plans as to how the student/class will keep a record of the new words they will be learning in this unit.

10. Start a list of marine environment and marine resource words. Put them on a large chart. Have the students learn how to pronounce each word and be ready to tell its meaning. Add to the list as new words are learned. Allow a few minutes each day or so at the end of the class period for the students to add new words to the list.

11. Start a class marine environment and resource dictionary. Use a loose-leaf notebook with one sheet for each word. Write the word and its meaning. Cut out a picture from a magazine or make a drawing to help show what each word means. Keep adding to the dictionary as new words are learned. Students may take turns preparing the pages.

12. You may have the students go to the library and find their own poem or you may bring books to class. (Your English and Literature teachers can help you. Good opportunity to involve teachers from other disciplines or community resource people who may have special knowledge of Literature of the Sea.) See references for one book of sea poetry of the past and another of today's poetry. May have students compare the poetry.

13. You may have the students go to the library and select a marine-oriented book to read and complete the Books of the Sea activity. Keeping a file of the students answers to the questions on each book can provide the class with an annotated list of marine books.

14. The Ocean World of Jacques Cousteau, Vol. 12 A Sea of Lengends: Inspiration from the Sea is one source of sea tales and legends. You may even have the students present their tale/legend to some elementary classes.

15. In the optional activity of identifying marine works in your school or local public library, you may wish to assign a small group of students to an area. The class may compile an annotated bibliography which can be used throughout the unit.

16. The Signals of the Sea may be used here or as part of Topic Fourteen--Transporation. You may want to use signal flags on a bulletin board to introduce topics or leave messages for your students. You may also want to use signal flags to give your student non-verbal messages instead of verbalizing them like Quiet, Sit Down,, Too Much Noise, etc.

17. References which might help with this topic are:

The Ocean World of Jacques Cousteau, Volume 7 Invisible Messages, Volume 12 A Sea of Legends: Inspiration from the Sea.

Americans and the World of Water, edited by Harold L. Goodwin, A Sea Grant Publication, University of Delaware Sea Grant College Program, University of Delaware, Newark, Delaware, 1971.

Oceans: Our Continuing Frontier, edited by H. William Menard and James L. Scheiber, Publishers, Inc. Del Mar, California.

The Sea, Ships and Sailors, Poems, Songs and Shanties, selected by William Cole, The Viking Press, New York (a full book of sea poems).

The Rhyme of the Modern Offshoreman, by L.C.S. Robus, Seamount Book Company, Houston (poems of today's offshore oil platforms).

TOPIC ONE--INTRODUCTION
EARTH IS A WATER PLANET

Write or complete--

A Syntu about the Sea.
The Sea and Me

Share--

Your syntu and your responses to "The Sea and Me" with your classmates.

Brainstorm and list--

All the ways you can think of that water or the marine environment has influenced man.

Share--

Your lists with your classmates.

Listen to and view--

Audio tape and slides on "Earth is a Water Planet."

Think--

About your concerns and feelings about the ocean.

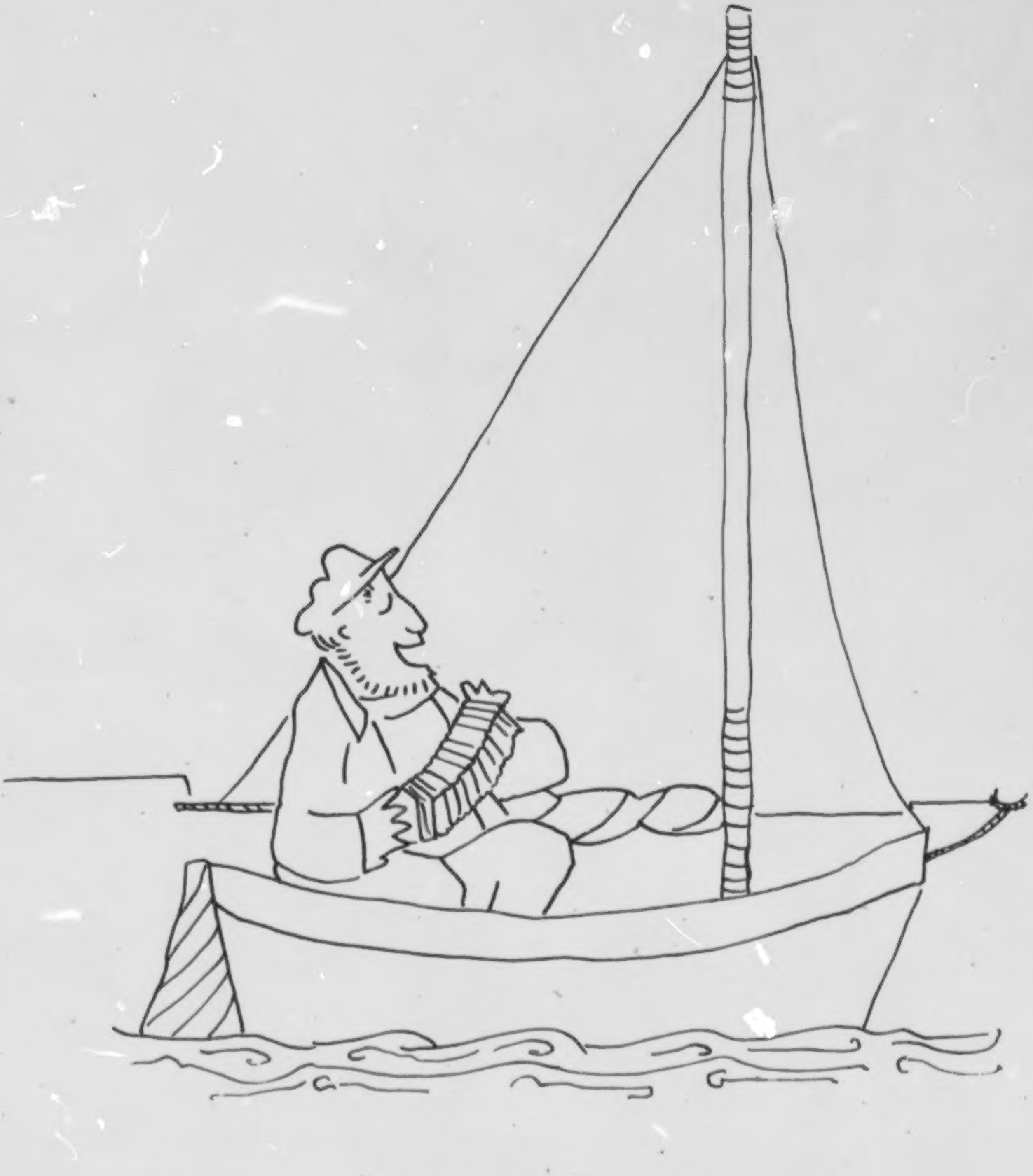
Make--

A collage of your concerns and feelings about the ocean.

Optional

Select--

A way that the sea affects man and report on it to your class by means of a story, play, music, song, drawing, painting, dance, model, etc.



A SYNTU ABOUT THE SEA

Write a syntu about the sea or the marine environment. A syntu is a Japanese Poem consisting of five lines. They do not have to rhyme. The lines are as follows:

In line 1 use one word -- the name of a marine animal, object, event or phenomenon.

In line 2 write an observation of the item you named in line 1 using one of the five senses.

In line 3 write a feeling about the item named in line 1.

In line 4 write another observation of line 1 using one of the senses not used in line 2.

In line 5 write a one-word synonym for line 1.

Write your syntu below!

THE SEA AND ME

Complete the following sentences:

What I like most about the sea is

What I like least about the sea is

When I hear the word sea, I think of

When I hear the word sea, I feel

The most worthless part of the sea is

The most priceless part of the sea is

The most meaningful part of the sea to me is

BRAINSTORM / INFORMATION SHEET

Purpose: To make a list of all the ways you can think of that water or marine environment has influenced man.

1. Divide into groups.
2. Choose a chairperson, one who keeps the ball rolling.
3. Select recorder(s) to write down every idea suggested.
4. Select a time keeper. Someone to keep track of the time for the group.
5. Time limit of 5 minutes.
6. All ideas welcomed. Nothing has to be explained. Expand on other's ideas. Help each other. Listen. Others may trigger something in your mind, and you may trigger theirs.
7. Work to get as many ideas as possible. See which group gets the longest list.
8. Goal: To make a list of all the ways you can think of that water or the marine environment has influenced man.
9. Share your lists.

VIEW FILMSTRIP/CASSETTE "EARTH IS A WATER PLANET"

Add to your list of all the ways you can think of that water or the marine environment has influenced man; as you learn from each other and the slides and tape.

EARTH IS A WATER PLANET

Slide 1:

Background music

Slide 2:

Background music

Slide 3:

Background music

Slide 4:

I'm Captain Al G. Seaborne. I have sailed the 7 seas on all kinds of vessels. However, I call the Gulf coast my home. Thank you for inviting me to speak to you on a subject I consider very important--"The influence of water on our Lives."

Slide 5:

The Apollo moon missions gave us for the first time in human history, a picture of our home--planet earth. When the astronauts saw earth, they called it, "the Blue Planet". Tell me, What do you think makes the earth appear blue? If you said "water", you are exactly right. Our earth is primarily a world of blue water partly concealed by patterns of white vapor clouds that mark the movement of the weather systems.

Slide 6:

The brown and green shapes are the land masses or continents. Which do you think covers more area--land or water? Did I hear you say "water"? Right again! The oceans cover nearly 71% or almost three-fourths of the earth's surface. So, our continents are actually islands in an enormous global sea.

Slide 7:

Life on this earth is water based! As we examine all the different life forms on earth, we find that some withstand great temperature extremes and some even live without oxygen. However, all rely on water for survival. In fact, did you know that your body is about 60 to 70 percent water? This means that you are also a water creature.

Slide 8:

Water runs throughout our bodies as it does throughout the earth. On earth, like in our bodies, water acts as a solvent and a transport system to remove poisons and wastes.

Slide 9:

Water is our most common solvent. It dissolves more substances than any other solvent. In sea water there are up to fifty-seven elements present including common table salt, zinc, gold, and silver. Since the solvent power is so great, it is rare to find water in a truly "pure" condition anywhere in nature.

Slide 10:

Another result of water's solvent power are the caverns, valleys, canyons and deltas on the face of this planet. Therefore we can say that water has actually helped give the earth its face.

Slide 11:

Even though water is an excellent solvent, it is easy to obtain water in a fairly pure state. Thus, we can use water as a scientific standard in many ways. For example, we use water as a standard to determine calorie, BTU and Specific Gravity. We also use water for graduating thermometers since the temperature at which water freezes and boils is the freezing and boiling point on a thermometer. So you see, water is really important--isn't it?

Slide 12:

Ever wonder what life would be like without water? With no oceans the earth would be intolerably hot during the day and miserably cold at night. Water modifies our climate by storing heat and redistributing it over the earth through ocean currents and atmospheric circulation. The sea is also the source of extraordinary climatic events such as hurricanes and tropical storms.

Slide 13:

Do you know that our language, in spite of its remarkable range and flexibility does not even have a common-use noun or adjective embracing the entire world of water in its various states from salt to fresh, and from vapor to ice? However the global sea is our planet's dominant feature. The Latin word for sea is mare, the source of our adjective marine. The common characteristic of all things marine is saltness. Consequently the marine environment is that environment which contains or is directly influenced by salty water. It also refers to the many ways in which water influences and affects our lives and the life and environment of all living things.

Slide 14:

Water draws us, capturing our attention and our imagination. From prehistoric times to the present, the sea has been an important theme in art, literature and song. The sea has been an inspiration for ballads, shanties, songs, symphonies and operas. The sea and its rhythmical movement has also inspired choreographers.

Slide 15:

Many terms and expressions of the sea have become part of our language today. A few of these are average A-1, first rate, taken aback, clean bill of health, out of commission, laid up, junk, on the rocks, freight, crew, overhaul, cranky and the bitter end.

Slide 16:

The sea influences our architecture as well.

Slide 17:

In countless ways, large and small, the resources of the sea touch our lives from the pudding in today's snap pack to the foam in beer to oil and gas in our automobiles. How many marine resources do you use directly or indirectly? More than you think!

Slide 18:

Initially, the major resource of the ocean was transportation. The Sea's role in transportation is equally valuable today. For example, only 10 out of the 50 states do not have contact with the sea directly or indirectly because of inland waterways.

Slide 19:

More and more we are turning to the sea as a source of energy. Energy from the sea has taken many forms and will take more in the future.

Slide 20:

One phenomena of our time is the tremendous increase in marine recreation. How many recreational activities can you list?

Slide 21:

When we examine the history of peoples and nations, we see that their movement has quite often been in response to the presence or absence of water. Our country has always been a maritime nation and even our major population centers are near water. Do you know that more than one half of our population lives only an hour's drive from the sea?

Slide 22:

Many people think of Texas as a land of ranches, cows, cowboys and oil wells. How many of you would think of Texas as a land of windswept beaches and soaring sea gulls?

Slide 23:

Texas actually ranks second in the United States in land area and third in length of coastline. Yes, the Texas shoreline is over 100 miles long.

Slide 24:

Do you know that there are fourteen major deep water ports located along the Texas coastline? The Port of Houston is the largest inland port and ships to 250 major world ports. Galveston is the world's largest cotton port.

Slide 25:

The port of New Orleans on the Gulf of Mexico is the second largest port in the United States while Corpus Christi is the ninth largest.

Slide 26:

In Texas, each of these ports is the location for petroleum refineries, bulk terminals and petrochemical plants. I'll bet you didn't know that this region contains more than 50 percent of the nation's petrochemical industry and 25% of its refinery capacity.

Slide 27:

Do you realize that this area is also the major spawning and nursery area for more than seventy percent of the fish and shellfish population in the gulf?

Slide 28:

Because we traditionally think of Texas as cattle country, it is difficult to realize that Texas is one of the nation's foremost producers of marine fishery products. More than 200 million pounds of fish and shellfish are landed annually on the Texas coast.

Slide 29:

Not long ago our view of the sea was filled with myths and legends. Attitudes and viewpoints have changed. The horrors of the deep have become the shy creatures of Jacques Cousteau's films. We had songs about the whale and now, we have recorded the song of the whale itself.

Slide 30:

The most profound change in our perception of the sea is that we now know that the ocean floor is not uniform, motionless or featureless. Instead it has mountains, plains, canyons and the continents are drifting apart. The history of the earth is not at all what it seems.

Slide 31:

The marine environment influences us but the balance is changing, How?, you ask. We have not fished the oceans clean, but we probably could. We have not poisoned them, but we probably could poison them. We have not significantly altered the vast open ocean, but near the cities we have.

Slide 32:

Even the open ocean is defenseless against the pollution of some new materials created by man. We also face the ultimate pollution of nuclear wastes, not necessarily those from power plants. Do you realize that a twenty minute exchange of nuclear rockets could poison the oceans?

Slide 33:

How does water influence us and our lives? How is the influence changing? How do we influence the marine environment? How do we measure up? What must we do? These are things we need to learn more about in the future.

Slide 34:

Well, it's been nice visiting with you. I'll be looking forward to sharing with you some additional things that I have learned about the marine environment in the activities that follow.

Slide 35:

The end.

COLLAGE OF CONCERNS AND FEELINGS

Think about the following:

What are your concerns about the ocean at the moment?

What in the ocean is important to you?

What are your feelings about the ocean?

What are your hopes and dreams for the ocean?

Now leaf through magazines and newspapers. Tear out titles pictures, words, slogans, and want ads that portray your feelings, concerns and etc. about the marine environment. Then past your tear-outs together on a sheet of newsprint and add color, design or graffiti with poster paints or magic markers.

TOPIC ONE--INTRODUCTION
WORDS, POEMS AND BOOKS OF THE SEA

Complete--
Words from the sea.

Look At--
Brief List of Sea Language Ashore.

Read--
Marine words.

Begin a List--
New words and meanings that you learn in this unit.

Read--
A poem about the sea.

Complete--
The poetry of the sea activity.

Share--
Poem you have read with your classmates.

Read--
Letters of the sea.

Read--
A book of the sea (informational fiction, biography, etc.)

Complete--
The books of the sea activity.

Share--
Your recommendation (the two reasons why or why not you would recommend it) with your classmates.

Read--
Tales of the sea.

Find and Read--
A tale or legend of the sea.

Complete--
The Tale of the Sea activity.

Prepare--
A presentation of the tale/legend to present to the class.

Optional
As a Class Complete--
A list of all marine books available in your school library.

Group--
The books as fiction, (specify type), informational, biography, poetry.

WORDS FROM THE SEA

Many terms and expressions of the sea have become part of our language today. However, their meanings have changed and they may not be used in the same way. A few of these words and their marine meanings are listed below. What is their meaning today?

Word	Marine Meaning/Use	Today's Meaning/Use
A-1	used to denote ships found to be in first class condition	
average	first designated an equitable division among all participants of a loss incurred in a shipment at sea	
cut and run	to "let run" the furled sails of a ship by cutting the yarns that secured them	
clean bill of health	a certificate stating whether there was an infectious disease aboard a ship or in the port which the ship is leaving; it is given to the captain for him to show at the next port	
crew	all men working on a ship	
cranky	liable to lurch or capsize	
freight	a method of transporting goods by water	
first rate	a ship in first class condition	
haul	to change the course of the ship by trimming sail usually so as to travel closer to the wind	
haul off	to change a ship's course so as to draw away from something	
haul up	to sail nearer the direction of the wind	

Word	Marine Meaning/Use	Today's Meaning/Use
junk	a worthless rope	
laid up	a ship that is dismantled and out of use	
out of commission	a ship not in fit condition for use	
overhaul	pull a ship's rope through a block or lead so as to ease or slacken	
on the rocks	a ship being ruined when it was grounded on rocks	
son of a gun	a reminder of the days when women lived on board the king's ships in the harbor and sometimes at sea too.	
taken aback	in an unmanageable condition because of the sudden shift of the wind striking the sails from the side opposite that to which they are trimmed	
to the bitter end	the bitter end is the part of a cable which remains within the spool	

You may want to see if you can find others.

SEA LANGUAGE ASHORE

There are many instances where words that we use are borrowed from the sea. Our common speech has many examples, but in using them most people are not aware of the connection. Other terms originated by seamen no longer have any relation to seafaring and have vanished from the sailor's tongue. Antenna is one of these. To the Roman sailor the spirit or yard on which he set his sail was an antenna.

The terminology of trade and transportation on land owes a heavy debt to the sea for its language. The railroads coined some new words, but others they borrowed outright. These included ballast, run, stateroom, aboard, shipping, fare, freight, berth, cabin, tender, caboose, crew. Other terms include charter, fleet (taxis or buses); dogwatch (newspaperman); on deck, and in the hole (baseball); contractor's *wrecking crew*; and the soda-fountain's *double deckers*. The airplane has also taken over many sea terms including pilot and skipper. The list could continue. Below is a brief dictionary of some of the sea language that has come ashore.

SEA LANGUAGE ASHORE

A

A-1: first-class; rating given to British naval vessels and merchant vessels for insurance purposes.
Aback: a ship being unmanageable due to a sudden shift of wind striking the sails from the side opposite that to which they are trimmed.
Aboard: inside the bulwarks, on deck or in collision.
Act of God: used with marine insurance meaning due to causes beyond human control.
After: the portion of ship behind mainmast where officers have their quarters.
Antenna: the sprit or yard on which a sailor set his sail
Arrive: to come to shore.
Articles: a written agreement by the crew signed before a government official before sailing.

B

Barge: a heavy, clumsy craft, with or without sails.
Beachcomber: a runaway sailor.
Bear Down: to approach another vessel from the windward.
Beat: to make progress in the direction from which the wind is blowing.
Below: beneath the deck.
Blanket: to cut off another vessel's wind by sailing close to windward of her.

Bring Up: come to a sudden stop, due to grounding.

C

Cabin: living accommodations aft for officers and passengers.

Caboose: cabin or deckhouse on a small vessel.

Call: summon from below decks.

Cast About: to try different courses when in doubt as to the ship's position.

To Make A Clean Sweep: of a sea breaking over the rail and wash overboard all movable objects.

Coast: make short trips from port to port.

The Coast Is Clear: originally refered to a blockading squadron.

Come Down Upon: to attack from the windward.

Cut Out: attacking a ship at anchor by means of a small boat.

D

Dead: word used to denote exact bearings like dead ahead.

Deck: horizontal partitions separating the sections of a ship's hold.

Derelict: a ship abandoned but still afloat and a menace to navigation.

Dragnet: a net used by fisherman for bottom fishing.

Driver: a shipmaster given to carrying soil.

Dungarees: Working-clothes of blue jean, first applied to sailors' clothes.

E

Ease Off: to steer less closely into the wind.

F

Fairway: a straight course down a channel.

Fare: a fisherman's catch of fish.

Fender: a buffer of wood or braided rope hung over a vessel's sides to prevent injury to her hull.

Figurehead: carving on a ship's bow.

Filibuster: to run contraband of war to revolutionaries.

First-rate: an official rating of warships in the British Navy of old.

Fleet: a group of ships in company

Freight: goods transported by ship.

G

Galley: an old-time vessel.

Glass: in the old days at sea, was half-an-hour measured from the sandglass or a spy-glass.

Greenhorn: a person making his first voyage.
Ground: to run a vessel ashore or aground.

H

Hail: to call out from one part of a ship to another.
Hand: a common sailor.
Hard Up: the rudder over is as far as it will go, so nothing further can be done.
Haul: a catch of fish.
A Clean Bill Of Health: certificate given by the port health officer to a departing vessel.
High And Dry: aground too far to be lifted by the tide.
Hold: Cargo space in a vessel.

I

Irons: sea name for handcuffs.

J

Junk: worn-out rope and ship's fittings.

K

Keep: to steer.
Knock Off: to go off duty.

L

Landmark: a prominent object on the coast, recognizable from the sea at a considerable distance.
Lash: to tie securely.
Launch: to set a newly-build ship afloat.
Lay Off: steer away from the wind.
Lay Up: to take a ship out of active service to make repairs.
Leg: the distance covered by a vessel.
Libel: to place a lien upon a vessel or cargo.
Light Out: go or carry out orders.
Lines: the design of a ship.
Locker: a compartment for stowage aboard ship.
Look Up: to head a vessel closer to the wind.
A Total Loss: a shipwreck with no possibility of saving the hull.
At Loose Ends: rope cast off the pin and dangling idly.

M

Manhandle: move cargo by sheer manpower.
Mate: first or chief mate of a vessel.

O

Off And On: a ship tacking toward and away from the land, waiting for daylight or the tide.
The Old Man: sailor's name for the captain.
Open and shut: alternate spells of clear and cloudy weather.
Overhaul: to overtake another vessel.
Overwhelm: bury in heavy seas.

P

Papers: all a ship's documents on hull and cargo.
Pay Off: to discharge and pay accumulated wages to the crew.
Pile Up: running a vessel aground.
Pipe Down!: sea slang meaning "shut up".
Push Off: to leave for.

R

To Rate: from ranks in the Navy.
Reckoning: calculation of a ship's position.
Ride: to lie at anchor.
Rostrum: bronze beak ram on early war-ships of the Mediterranean.
Rover: a pirate.
Run: distance covered by a vessel in a given time.
Run Down: to be in collision with another ship by running into her.

S

Salted Down: saved or hoarded.
Salvage: a claim on the value of a vessel and cargo abandoned at sea, by another vessel that brought them to safety.
Scuttle Butt: a cask of drinking water which stood on the deck of old-time vessels for the convenience of the crew.
Shake A Leg: used in calling the watch below.
Sheer Off: to change course away from an object.
Sheet: first meant sail.
Shove Off: push a boat away with oars.
Skyscraper: a small triangular sail carried on some ships above or in place of the skysail.
Sleep In: to sleep through one's watch on deck.
Slush: waste fat from the kitchen, used to grease the masts.

T

Tally: to keep track of items of cargo going in and out by means of tally marks, four upright strokes with a fifth diagonal stroke linking them together.
Tender: a small boat serving a larger vessel.
Trip: a short voyage.
Turn In: to go below at the end of one's watch.

Turn Out: to go on duty.

U

Underwrite: meaning to share the risks among subscribers called underwriters, first used on vessels at sea.

V

Vamoose: get out of here.

W

Way: progress of a ship or boat through water.
A Whale Of: something large and important.
Wreck: the remains of a ship or to wreck a vessel is to cast her away.

Y

To Spin A Yarn: in making spunyarn from untwisted yarns of rope, it took two sailors to operate the winch.

MARINE WORDS

Words are created, flourish and fade away as their need disappears. A hundred years ago, the Nantucket whaler spent his free time doing scrimshaw work. Today the Nantucket whaler is gone. So there is little need for a word meaning etching on ivory.

Today there is a need for new words. A large number of people are discovering, inventing, and doing new things related to the ocean. The surfer and oceanographer need new words to describe the waves. The geologist needs new words to describe the sea floor and its spreading. The lawyer needs new words to describe legal matters concerned with the sea. The oil company executive needs new words to order a platform for drilling oil in deep water.

The need for terms related to the mineral resources of the sea is relatively new simply because we have not begun to extract minerals from the sea floor. Surface vessels have gradually changed over the centuries as capabilities have increased and needs have changed. The oil tanker has grown and changed to the point where it has a new name, very large crude carrier (VLCC). We have greatly increased our ability to do things under water during the last few decades. So now we have aqualung, bathyscaph, diving saucer, deep submersibles, Sealab, Conself, Tekite and JIM to name a few.

Confusion may be expected when new words are created. People use them in different ways. There may be several new words to describe one thing. Of course, the meaning of the word may change. A word that is satisfactory for one purpose may be used for another purpose for which it does not fit. All these new words and concepts can lead to confusion. Nothing can be done about this. By the time the words are standardized and in dictionaries many of them are out of date.

To help us learn the new words and concepts and to avoid all the confusion, we will develop our own dictionary or word list. You may begin today and add to it as you learn new words, meanings and concepts.

POETRY OF THE SEA

Read a poem about the sea.

Name of poem ____

It was written by ____________________________________

What is the setting (time and place)? __________________

Is it real or imaginary? ______________________________

What does the poem do?

a. Tells a story _______
b. Presents a picture _______
c. Expresses emotions _______
d. Teaches a lesson ______

It says the sea is __________________________________

____

The writer's feelings about the sea are _______________

____

The poem makes me feel ______________________________

Would you recommend this poem to a classmate? Give two reasons why or why not.

____

____

Would this poem be written the same if it were written today? Explain.

____

____

Would the author write the same poem if he were writing about the sea in the year 2000? What would be the same? What would differ?

____

____

LETTERS OF THE SEA

Restless and changing, awesome and mysterious, the sea has gripped our imagination throughout the ages. Writers and playwrights have long been fascinated by the mysteries of the ocean. These visions are expressed in our literature. Homer of ancient Greece wrote the first great sea epic, the Odyssey. In his epic, the sea has an image that is full of danger and peopled with sea monsters. Writing about the sea continued even with the American writers.

James Fenimore Cooper, the first great American story teller is remembered as the author of novels about Indians and pioneers. However, he also wrote of the sea. His first sea story was The Pilot based on John Paul Jones and the cruise of the Ranger. It was the first American sea novel upon its publication in 1823. One of his last books was also a sea story, Afloat and Ashore (1844).

The writing of the sea continued. Richard Henry Dana, Jr. sailed around the Horn and the story of his adventures became one of the great classics, Two Years Before the Mast (1840). Herman Melville sailed on one of the whaling ships. This resulted in his first book of the sea, Typee, which was followed by several others. He ended with his masterpiece, Moby Dick. Moby Dick is a complex book like the sea itself with many levels. It was America's attempt to wrestle with the meaning of the seas and continents of the moral world. Among the papers he left behind when he died was the completed novel, Billy Budd.

Henry David Thoreau did know Melville's first book Typee, but he disliked fiction and he did not read Moby Dick. So in Walden, published in 1854, he did not share the enthusiasm for expeditions exploring the seas. Even before he published Walden, he began his own experience with the sea. He died before he could put his book together. The book, Cape Cod (1858), composed of his essays, was put together after his death. It is about his walks, the people and flotsam and jetsam of Cape Cod.

When Melville died, young Jack London was beginning around the waterfront. He wrote one great sea story, The Sea Wolf, in 1904. In the 1930's Charles Nordhoff wrote a number of books about the sailor's life and on whaling and fishing. These were the Bounty triology, Mutiny on the Bounty (1932), Men Against the Sea (1934), and Pitcairn's Island (1934). These books inspired motion pictures and did much to remind American readers of their own seagoing past.

Two of our best known writers, John Steinbeck and Ernest Hemingway, wrote of the sea--Steinbeck in The Pearl (1945) and Hemingway in The Old Man and the Sea (1952). Steinbeck as a youth wanted to go to sea as Jack London had but was not able to get a job. He wrote The Sea of Cortez (1941) which deals with man interacting with the sea. In Cannery Row (1945) Steinbeck presented the image of a marine biologist who is the opposite of an establishment scientist.

The most widely read book about the sea in our times has been Rachel Carson's The Sea Around Us (1951) which deals with man's continuous confrontation with the sea. She also wrote Under the Sea Wind (1941) and The Edge of the Sea (1955). There are many other books of the sea and the writing of the sea will continue to intrigue man.

BOOKS OF THE SEA

Name of the book ______________________________

Author(s) of the book ______________________________

Author's background ______________________________

Type of book (check one)

- Informational ____________
- Fiction
  - Realistic fiction ________
  - Historical fiction ________
  - Fantasy ____________
  - Mystery ____________
  - Science fiction ________
  - Other ____________
- Biography ____________
- Other (explain) ________

Would you recommend this book to your classmates? Give two reasons why or why not.

Questions for information books:

1. Are the facts accurate and is the subject well covered?
2. Is the language interesting and realistic?
3. Evaluate the use of the illustrations.
4. On the back of this page write a 150 to 200 word summary of the information the book presents.

Questions for fiction books:

1. How does the author establish time and setting and how does it influence the action, setting, characters, or theme?

2. Who tells the story? Is the plot believalbe?

3. Briefly describe the plot.

4. Describe the main characters.

5. Is there a moral or lesson to the story? Explain.

6. What is the role of pictures in the book?

Questions for biography:

1. Who is the book about?

   Where was the person born?

   When?

2. What is the person well-known or famous for?

3. What were the person's strengths and weaknesses?

4. What part of the person's life does the book cover?

5. List three things you learned about the person.

TALES OF THE SEA

Every part of the world has its legends and tales of the sea. The very creation of the seas is explained in mythology and in the Bible. Fish also appear early in myth and religion. The Carthaginians worshipped the fish as a symbol of strength; the Egyptians regarded the eel as sacred; and the Chaldeans worshipped the fish-god Cannes.

Stories of great floods are found in most societies. The most familiar flood story is Noah and the Ark of the Bible. The ancient Greeks in their imagination developed the sea nymphs. There also are the legends of the lost continent--Atlantis. There are many legends of the sea from Odysseus in Homer's epic, the Odyssey. Some of the other stories are: Jason and the Argonauts; Gilgamesh; How the Fish Got in the Sea; Why the Fish do not Speak; Why Fish have Gills; Why Jellyfish Have no Shell; Why the People of Raiatea have no Fear of Sharks; The Boy Who Was Caught by a Clam; Why the Sea is Salt; The Origin of the Coconut; The Gratitude of the Fish; Mermaid of the Magdalens; and others. There is also Jules Verne's Twenty Thousand Leagues Under the Sea. There are many more stories and or legends of the sea.

Create your own tale or legend of the sea or outline your presentation of a tale of legend below:

TALE OF THE SEA

Name of the tale or legend ______________________________

____.

Where did you find it? (book) ______________________________.

Where did it originate? (people or country) ____________________.

Would you recommend the tale to your classmates? Give two reasons why or why not.

What is the setting and mood?

Describe the main characters.

What is the theme or main idea of the tale or legend?

Is there a moral or lesson to the story? Explain.

With a group of your classmates, plan a short presentation of the tale/legend to your classmates. You may want to do it as a skit, play, T.V. drama, radio program, puppet show, ballet, or make pictures to illustrate it. There are also other possible ways of presenting it. Outline the plans for your presentation below. Also identify each person's responsibility for completing the presentation.

TOPIC ONE--INTRODUCTION

SIGNALS OF THE SEA

Read--

Signal Flags.

Discuss--

The advantages and disadvantages of signal flags.

Use--

International signal flags and penants reference sheet to make signal flags.

Exchange--

Messages across the room.

Select--

One or more activities from the Signal Flag and Communication activities to complete.

SIGNAL FLAGS

Throughout the ages, flags have been used to communicate in the marine world. The flags are important signals to ships and boats. They have been used by the navies and even used by pirate ships to get in range of their prey. They can be used in many ways.

The flags are an international system of communication since they can be understood by anyone regardless of the language spoken. They do not need electricity so the flags can be used if there is a breakdown in the power source of other communications equipment.

The international code of flags and pennants uses 26 alphabet flags, 10 numerical pennants, 3 repeater pennants to indicate repetition of letters or numbers above them and an answering pennant. The flags or pennants are flown in vertical order with the first world or message on top. Words or abbreviations can be spelled out. A single alphabet flag flying alone has a standard meaning. Certain paired combinations relay specific messages. Special coded combinations of any number of flags can be used for secret messages.

Use the worksheet of the international signal flags and pennants as a reference sheet to use in making your flags and pennants and sending your messages. Find out what messages are sent using single letter or two-letter combinations using the international flag code. Exchange messages across the room, between classes or between buildings.

To help learn the code, have a spelling bee using signal flags.

INTERNATIONAL FLAGS AND PENNANTS

☐ Leave white

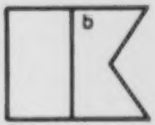
r Color red

b Color blue

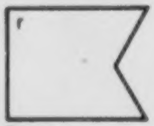
y Color yellow

bk Color black

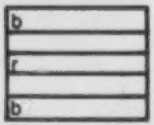
ALPHABET FLAGS



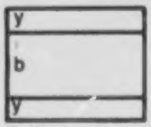
Alfa
Diver down; keep clear



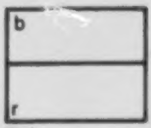
Bravo
Dangerous cargo



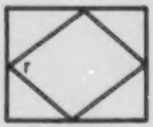
Charlie
Yes



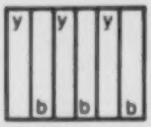
Delta
Keep clear



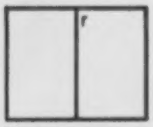
Echo
Altering course to starboard



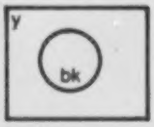
Foxtrot
Disabled



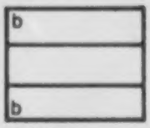
Golf
Want a pilot



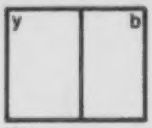
Hotel
Pilot on board



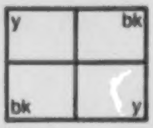
India
Altering course to port



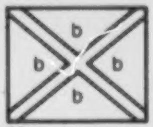
Juliett
On fire; keep clear



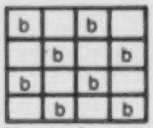
Kilo
Desire to communicate



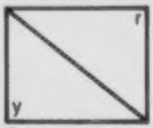
Lima
Stop instantly



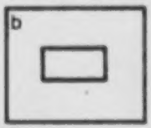
Mike
I am stopped



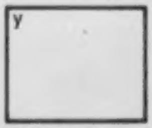
November
No



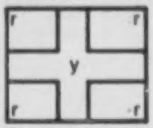
Oscar
Man overboard



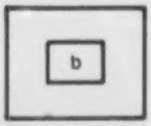
Papa
About to sail



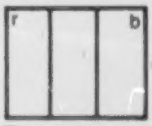
Quebec
Request health clearance



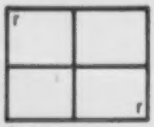
Romeo
(No message)



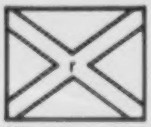
Sierra
Engines going stern



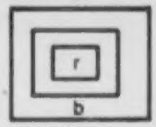
Tango
Keep clear of me



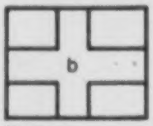
Uniform
Standing into danger



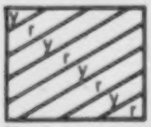
Victor
Require assistance



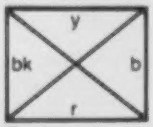
Whiskey
Require medical help



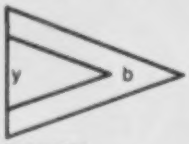
Xray
Do not carry out your plan



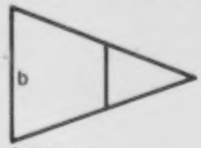
Yankee
Am dragging anchor



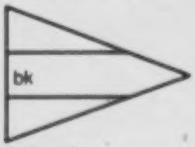
Zulu
Require a tug



1st repeater

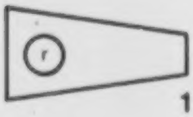


2nd repeater

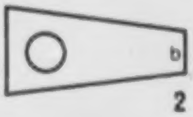


3rd repealer

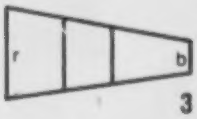
NUMERICAL PENNANTS



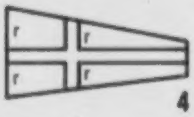
1



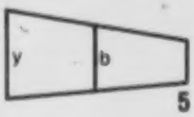
2



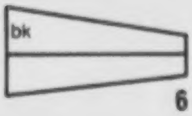
3



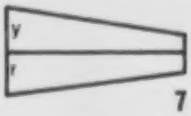
4



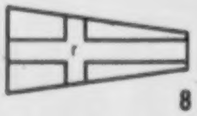
5



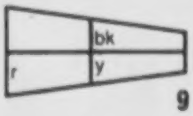
6



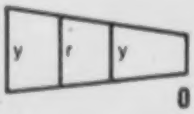
7



8



9



0

SIGNAL FLAGS AND COMMUNICATIONS

Signal Flag Spelling Bee

Have a spelling bee to practice the use of signal flags. Spell out a message with signal flags and the contestants must identify the message or give the contestants a message which they must spell out using the signal flags. (Remember the messages are spelled vertically with each flag below the other.)

Alternative system

Try to design a simpler or alternative system of designs and color combinations for a complete set of alphabet and numerical flags. Experiment to see which patterns are the most readable.

History

Use the library to find out about the history of signal flags or the importance of signal flags in history.

Semaphore

Semaphore is a system of visual signaling in which the sender holds a flag in each hand and moves his arms to different positions according to a code alphabet. Semaphores are used between ships or by the railroad. You may want to make semaphore flags in your school colors. You may then want to use the semaphore flags at your school spirit rally, sports events or other events.

Research

Use the library and/or individuals to investigate and report on related topics in communications for marine science including ship--ship, ship--shore, ship--diver, diver--diver signals; navigation lights and markers; use of T.V., radio, satellite and computer technology; and communication among marine organisms.

TOPIC TWO--THE SHAPE OF IT!

ACTIVITY ONE--Trip into the Depths of the Gulf
ACTIVITY TWO--The Ocean Floor

Materials for Classroom Use:

Physiographic Provinces of the Gulf of Mexico/drawing
Trip into the Depths of the Gulf of Mexico/reading
Sketches of Continental Shelf, Slope, and Abyssal Plain, GOMUER Vessel
Cross section view of Gulf of Mexico/drawing
Chart of Characteristics of the Floor of the Gulf
Topography of the Ocean Floor
Features of the Ocean Floor/Cross Section drawing
Mural of the Ocean Floor
Exploring *Terra*/activity

Major Objectives for the Topic:

After completing the activities the student will be able to:

1.5 identify the characteristic features of the ocean basins;
1.5 construct a model or diagram of an ocean floor;
1.5 identify the problems of learning about the ocean floor.

Teaching Suggestions:

The purpose of this lesson is to present information on the features of the floor of the ocean and Gulf of Mexico and to help the student to realize that the ocean floor is not featureless.

1. Have the student look at the drawing of the Physiographic Provinces of the Gulf of Mexico. You may wish to tape the Reading "Trip into the Depths of the Gulf of Mexico"; or have some students (drama or speech) make a tape of it; or you or a student read it to the class and have them listen to it. To make it more realistic turn out the lights in the classroom so it will be dark like the ocean depths. Have students look at other drawings, respond to questions and complete the activities.

2. Have student look at the drawing of Features of the Ocean Floor and read Topography of the Ocean Floor. The construction of the clay model of the ocean floor and then submerging the model into a glass container of water is an excellent way to illustrate the concept that the features of the ocean are like land which has been covered by water.

3. Have the student construct a mural on paper which can be placed on the wall of the classroom. In later activities they will add organisms, etc. to the mural.

4. The Exploring Terra activity is designed to help students grasp the idea of the difficulty of learning about the ocean world by reversing the position of having them probe the land by probes like we have done with the ocean. This will hopefully help them grasp the difficulty of exploring the ocean and why each investigation provides us with new knowledge and a better description of the ocean depths. Hopefully it will also help them understand why we do not have detailed maps of much of the ocean floor. Also help them to understand why we only know as much about the ocean depths today as we knew about the area of what is now the United States before the Lewis and Clark Expedition into the Louisiana Purchase. Point out to the students that dropping a piece of paper onto a map is affected by air currents like our dropping a probe into water is affected by water currents. There are other technical problems (identifying location of probe, depth, rocks below surface, etc.) you may note or have the students note. After the initial probe by the class together you may want to have the students work in groups and each group doing their own probes and compiling their own description of Terra. Once each group has compiled their description of Terra have the class discuss the descriptions. You may even have each group represent a different ocean country who is probing a different area of Terra like one group for each continent (include the poles.) They may use books of the different countries to help them describe the area around the probe. After the first series of probes, you may have them control and plan their probing so they can study an area in detail. They could also plan what areas they want the Terranauts to land on and investigate more thoroughly. The possibilities and limitations of this activity will be determined by you and your students. You may expand and extend it to organisms, resources, etc.

The New Ocean Explorers: Into the Sea in the Space Age by Howard Pennington, Little, Brown and Company, 1972. Its discussion of man's efforts to find the submarine Thresher and the hydrogen bomb lost in the depths of the Mediterrean gives an excellent example of how little we really know about the ocean and we need to develop to counter underwater exploration problems.

5. You may have the students collect information on the instruments and methods scientists use to learn about the ocean. This might be a library research project.

6. Encourage the students to read articles and/or report on the exploration and study of the ocean floor.

7. The following articles would be excellent for the students to read for additional information on the exploration and study of the ocean floor. They are all found in the National Geographic Magazine.

"Diving into the Blue Holes of the Bahamas" Vol. 138, No. 3 (Sept. 1970) pp. 347-363.
"Deepstar Explores the Ocean Floor" Vol. 139, No. 1 (Jan. 1971) pp. 110-129
"Tektite II: Part One-Science's Window on the Sea" Vol. 140, No. 2 (August 1971) pp. 256-289.
"Tektite II: Part Two-All-girl Team Tests the Habitat" Vol 140, No. 2 (August 1971) pp. 290-296.

"Diving Beneath Arctic Ice" Vol. 144, No. 2 (August 1973) pp. 248-267.
"Project FAMOUS-Where the Earth Turns Inside Out" Vol. 147, No. 5 (May, 1975) pp. 586-603.
"Project FAMOUS-Dive into the Great Rift" Vol. 147, No. 5 (May 1975) pp. 604-615.
"Window on Earth's Interior" Vol. 150, No. 2 (August 1976) pp. 228-249.
"Oases of Life in the Cold Abyss" Vol. 150, No. 4 (October 1977) pp. 441-453.
"The Continental Shelf-Man's New Frontier" Vol. 153, No. 4 (April 1978) pp. 495-529.
"Undersea Wonders of the Galapagos" Vol. 154, No. 3 (Sept. 1978) pp. 362-381.

TOPIC TWO--THE SHAPE OF IT!

TRIP INTO THE DEPTHS OF THE GULF

Look at--

Physiographic Provinces of the Gulf of Mexico.

Read/or listen to--

"Trip into the Depths of the Gulf of Mexico."

Imagine--

The features of the floor of the Gulf of Mexico.

Draw--

Picture to illustrate any part of "Trip into the Depth of the Gulf of Mexico".

Share--

Your drawings and impressions with your classmates.

Label--

Sketches of the continental shelf, slope and the abyssal plain.

Look at--

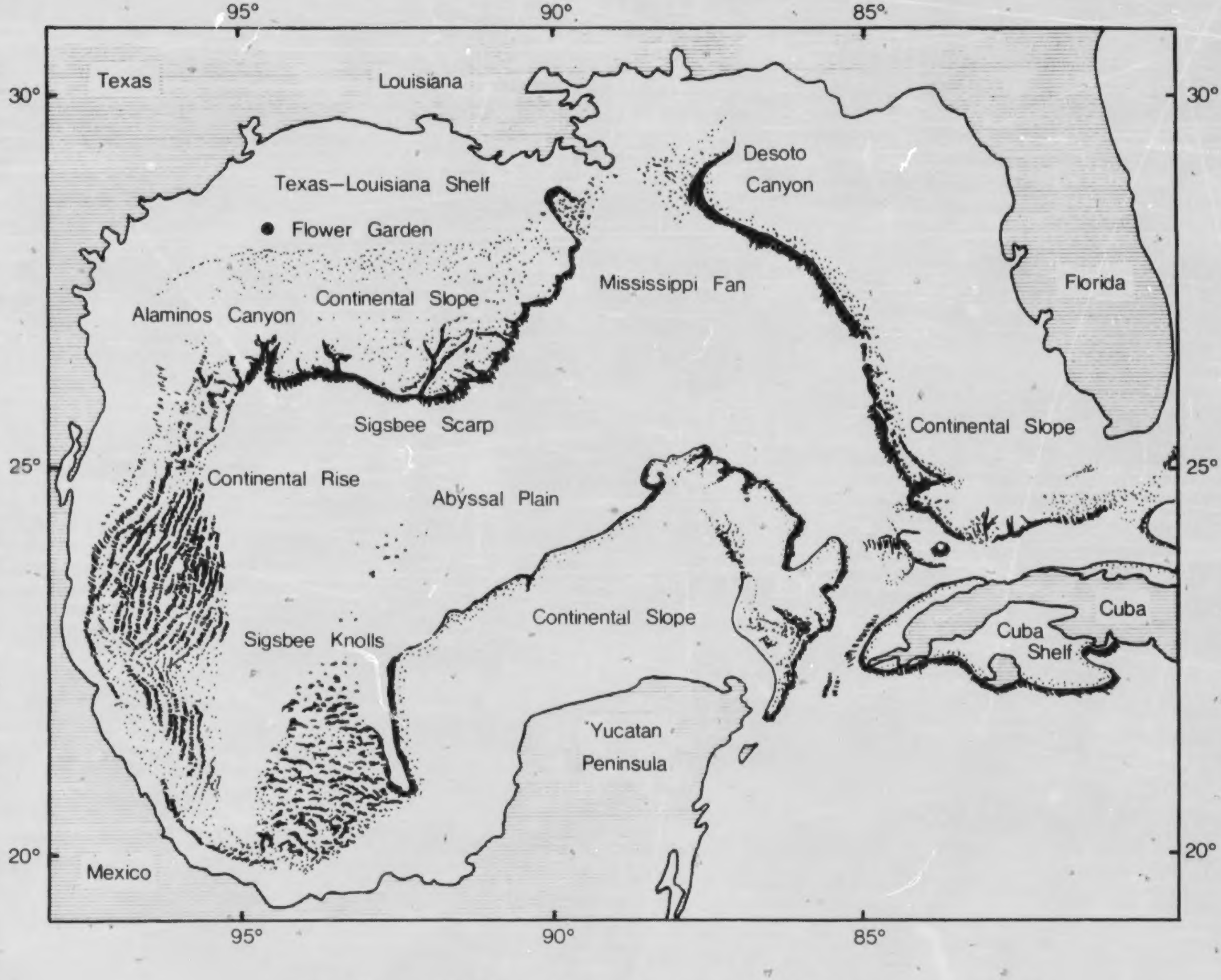
Cross section view of Gulf of Mexico.

Complete chart--

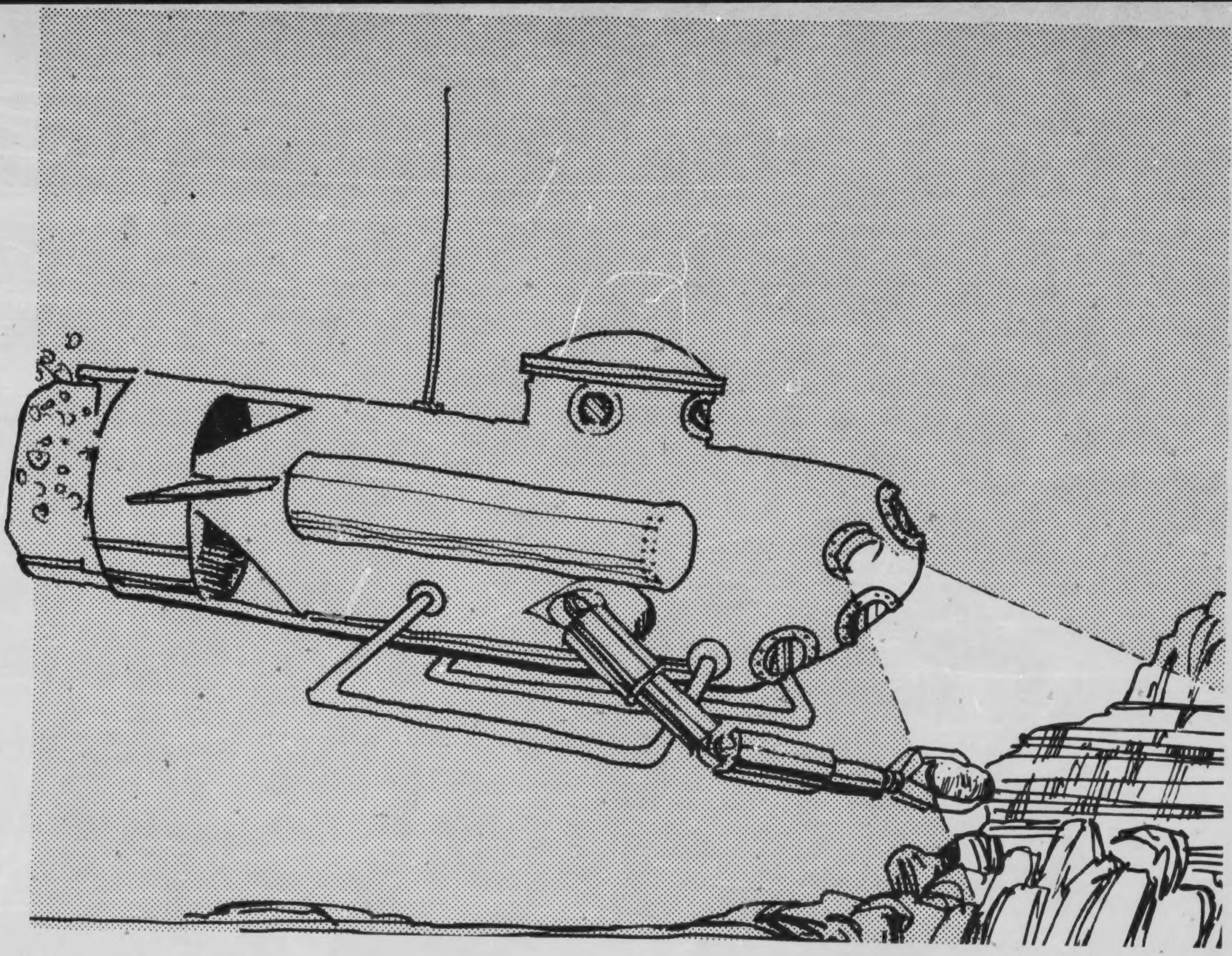
On characteristics of the floor of the Gulf.

Answer--

Questions on features of the ocean floor.


95°
90°
85°
30°
25°
20°
Texas
Louisiana
Desoto Canyon
Texas–Louisiana Shelf
● Flower Garden
Mississippi Fan
Florida
Continental Slope
Alaminos Canyon
Sigsbee Scarp
Continental Slope
Continental Rise
Abyssal Plain
Continental Slope
Sigsbee Knolls
Cuba
Cuba Shelf
Yucatan Peninsula
Mexico

Physiographic Provinces of the Gulf of Mexico



TRIP INTO THE DEPTHS OF THE GULF OF MEXICO

Put your head on your desk and close your eyes. This is Captain Seaborne. You and I are going to take a trip along the bottom of the Gulf of Mexico. You have been chosen to be the first student to go into the depths of the Gulf. A black limosine pulls up in front of the school and a man in a blue suit comes to your room to get you. You are driven to Galveston. Two oceanauts or aquanuats meet you. You do not need any special clothes since the pressure, air, and temperature is regulated inside the passenger chamber. The aquanauts are trained to operate the minisub GOMUER (Gulf of Mexico Underwater Exploration and Research) which will take you into the depths of the ocean. You now enter the sphere in which passengers are housed. The sphere is the best shape for withstanding the extreme water pressure of the ocean depths. Your minisub is made of a new titanium alloy only 2 inches thick which has withstood water pressure at depths of 23,000 feet. You will be looking out of thick, round, plexi-glass portholes.

Now all is ready for the trip. The doors to your chamber are locked. The signal is given to submerge and move away from the beach. As you leave the beach, the land below is the continental shelf. It slopes out from the beach. The depth of the water generally ranges from 0 to 600 feet with an average depth of 400 feet. The average width of this area is about 40 miles. Here in the Gulf, the width varies from 8 miles along the coast of Mexico to 117 miles along western Florida.

The continental shelf is actually part of the continent that is under water. Therefore shelf area resembles the Gulf coastal plain. Not only is it like the adjacent land, it also has the same minerals as the area of the continent of which it is a part. It appears flat and occasionally you see small hills. These small hills have algae reefs on top. They were formed a million years ago when the level of the water was lower. During the Ice Age when water was drawn up into glaciers the sea levels of the world dropped some 500 feet. So this was not under water during that time.

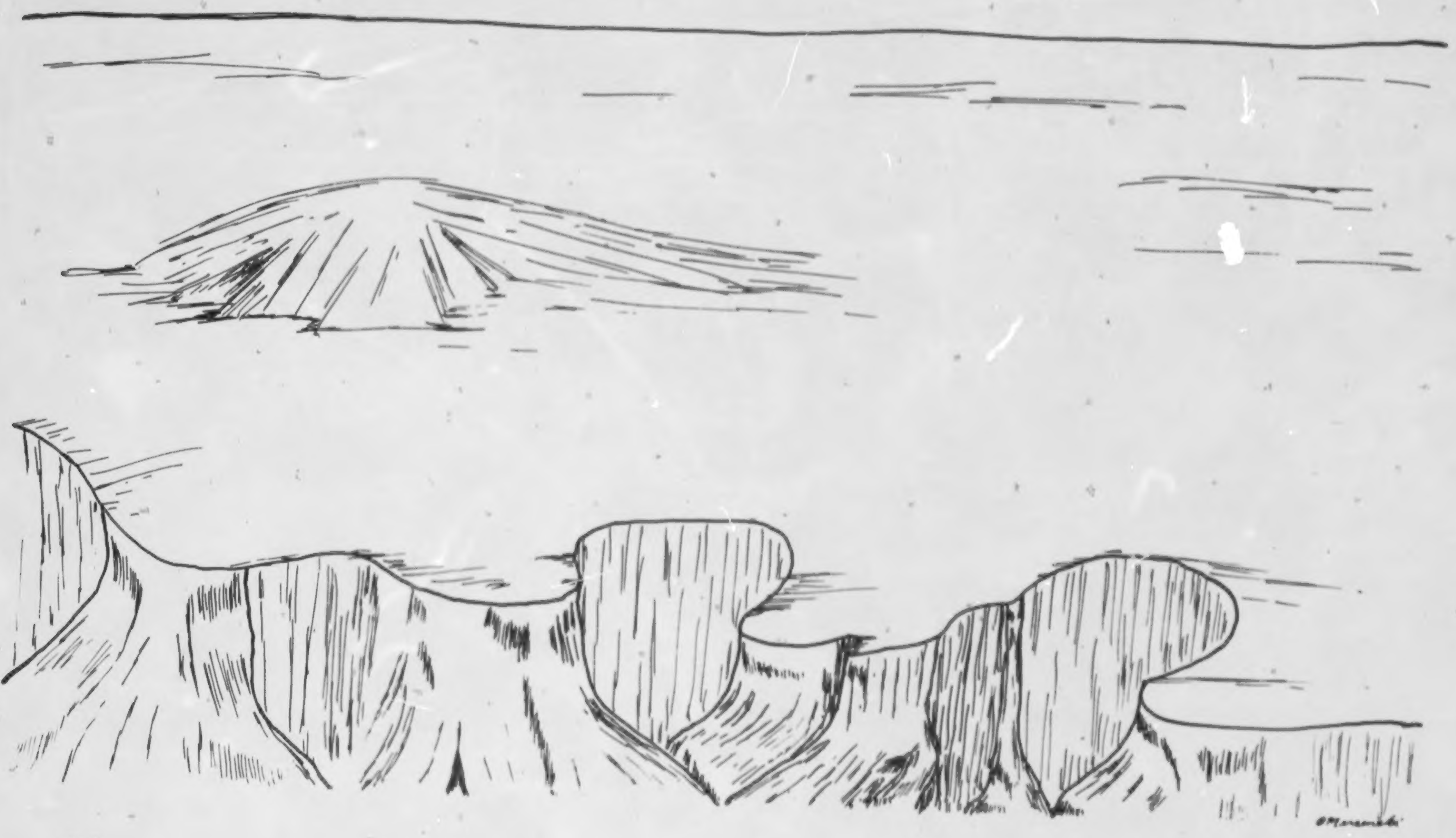
You are now about 100 nautical miles from Galveston. As you look out of the minisub, GOMUER, you see coral of all colors around you and at least 40 different species of fish. You are in the Flower Gardens Reef which has formed on a rise formed by one of the many salt domes under the Gulf of Mexico. This is the northern-most coral reef in the Gulf and Atlantic Ocean. The water around you is calm today so you are able to see the surface which is 60 to 80 feet above you. As you look around, you see that the reef covers an area of 2 to 3 football fields. The aquanuats tell you that there are other coral reefs in the Gulf but they are not living.

As your minisub moves seaward again, you see that the slope is much steeper and the sub is moving down. This area is the continental slope. The slope is 15 to 90 times steeper than the shelf. This is steeper than going down our steepest mountains on land. We have now dropped to a depth of 10,800 feet. (The average depth for continental slopes is 12,000 feet; some are much deeper). As the minisub moves down the slope, you notice that it is getting darker and you no longer see any plants. One of the aquanauts turns on the flood lights so you can see. The light shows you that the slope is cut by canyons, gullies and small valleys. As the sub turns west, or to your left, the light picks up the features of a spectacular canyon cut into the slope. This is Alaminos Canyon. The aquanaut points out that it begins on the shelf and that many canyons of this type are an extension of a river on a coastal plain and continue down the continental slope as far as the deep ocean. At the seaward end of the canyon, you see a large featureless apron sloping very gently seaward. This is built from sediment from the continent which flowed through the canyon and was deposited on the ocean floor. You are told that this sediment, which is thick enough to bury the bottom features, is the continental rise. Also, the Gulf of Mexico receives all the sediments from all of the United States lying between the Rocky and Appalachian Mountains. The Mississippi River alone brings a load of sediment of approximately 2 million tons into the Gulf each day.

As the minisub leaves the continental rise behind, you are at a depth of 11,875 to 11,930 feet. It is dark, and you can only see with the use of lights. This is the Sigsbee Abyssal Plain, the floor of the Gulf. The ocean basins are 2.5 miles to 3.5 miles deep which is deeper than the floor of the Gulf. Also the deep-ocean basins account for 30% of the earth's surface. This vast area of the Gulf floor has been buried by the sediments from the Mississippi and other rivers to form the plain which is flatter than any plains on land. You see a series of hills which rise 1200 feet above the plain. The sub now turns right and heads out the Sigsbee Deep, the deepest point of the Gulf which is 12,425 feet in depth. The trenches of the oceans are much deeper than the Gulf, the deepest is the Marianas Trench which is in the Pacific Ocean and is 36,000 feet deep.

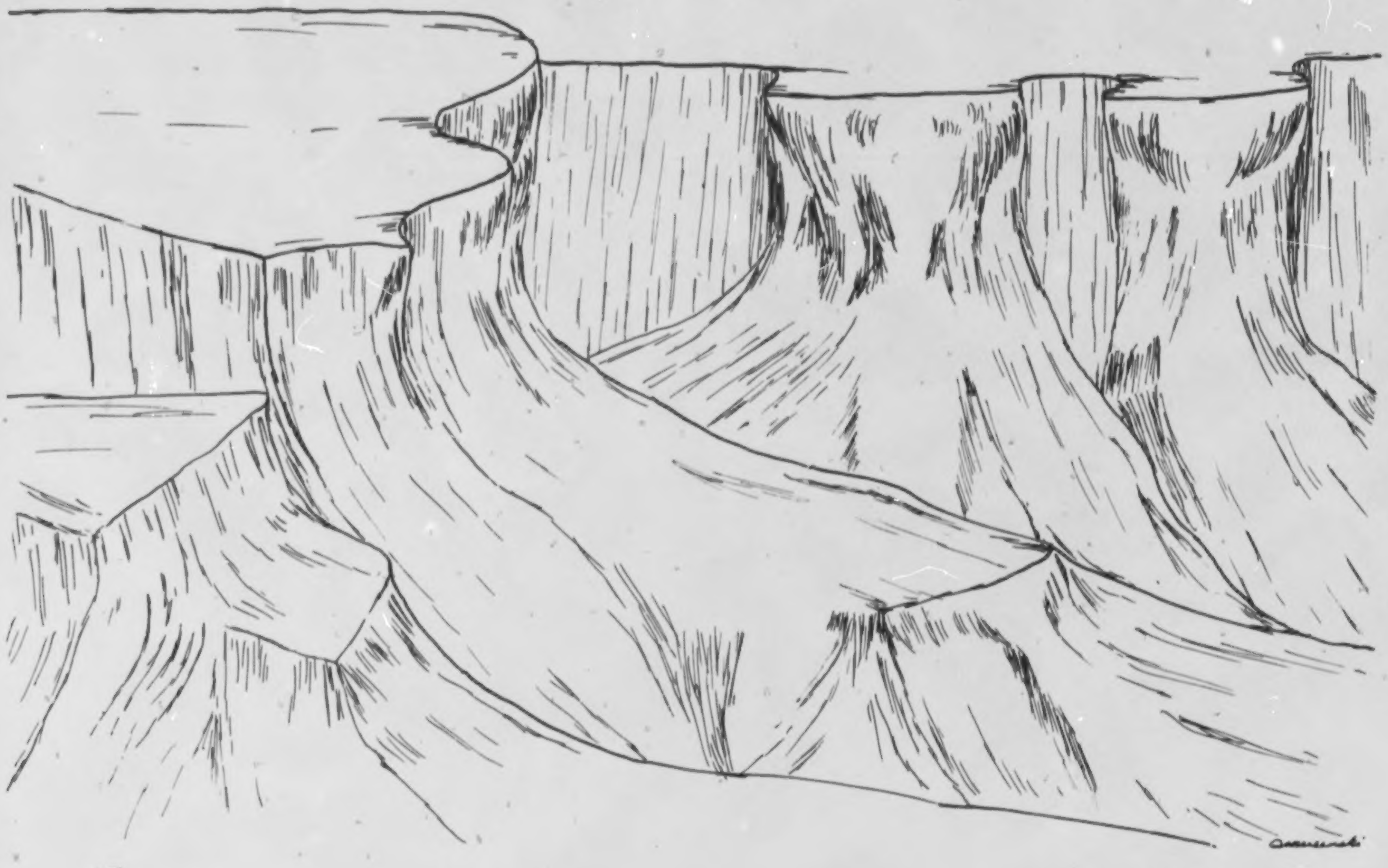
Now it is time for your submersible to head back to Galveston and surface. Hope you had a good trip. Reporters are asking you about what you saw. The photographs taken by the cameras in the minisub will not be available for a couple of days. Use the paper and materials the teacher gives you to draw a picture of any part of your trip you want to share with others. Or make a sketch in the space below. Share your drawings and impressions with your classmates.

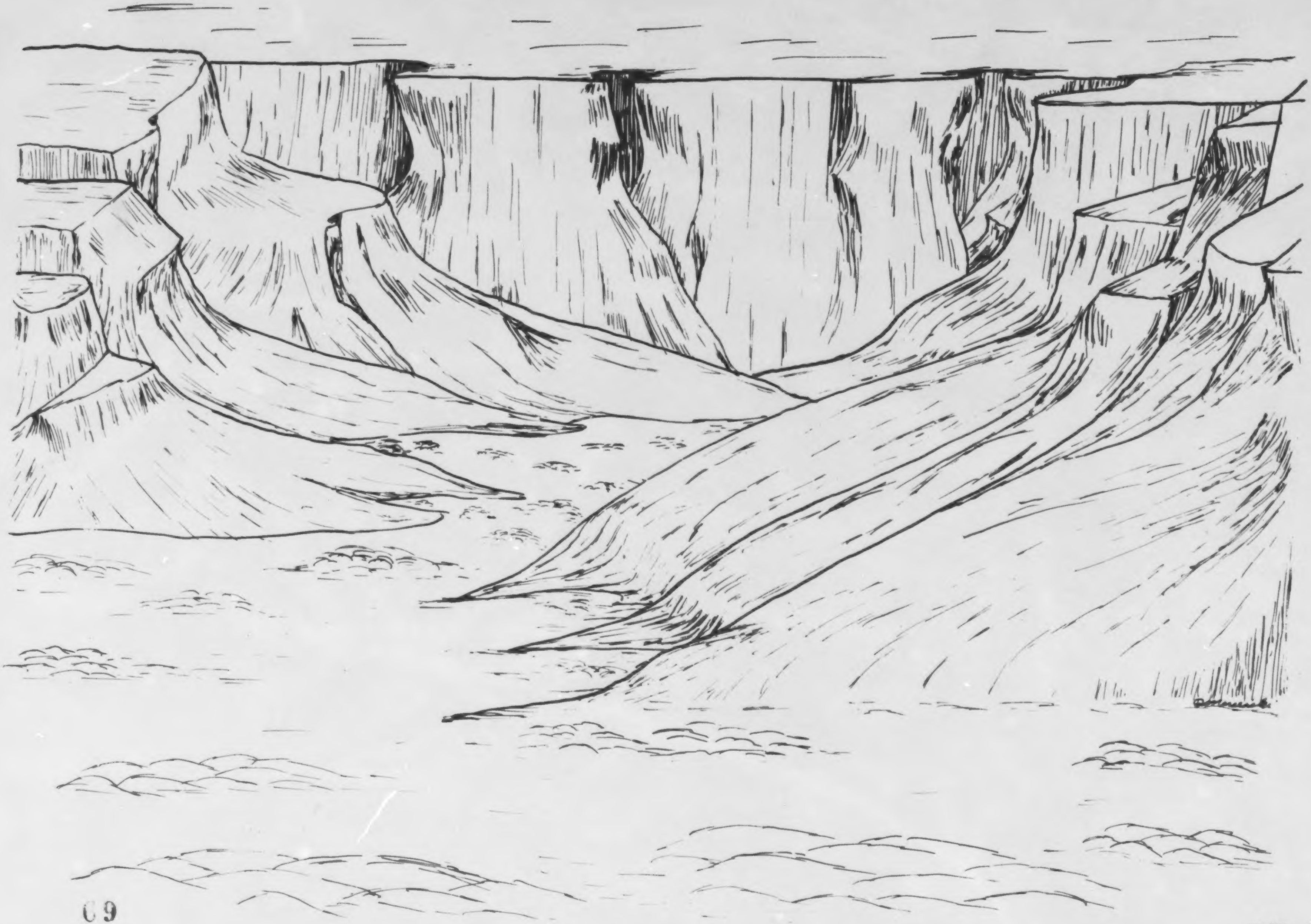
As you were leaving the minisub, one of the aquanauts gave you some sketches he made of the shelf, slope and plain. He didn't label them. Label the sketches. Did you label them correctly?

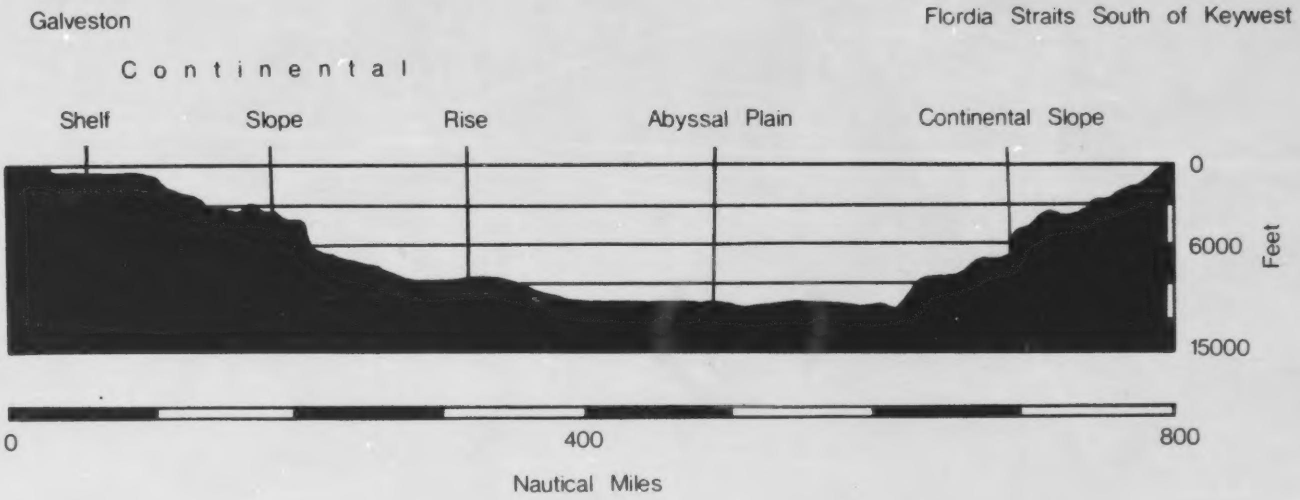


65

66






Galveston
Flordia Straits South of Keywest
Continental
Shelf
Slope
Rise
Abyssal Plain
Continental Slope
0
6000
15000
Feet
0
400
800
Nautical Miles

Cross Section View of Gulf of Mexico on a Line Between Galveston and the Florida Straits South of Keywest

Fill in the chart. Based on your trip and using the aquanaut's sketches, the diagrams of the cross section of the Floor of the Gulf of Mexico, and the ocean floor and the reading on the Topography of the Ocean Floor, see if you can fill in the following chart.

	Description & Location	Depth	Width Size	Surface Appearance
Continental Shelf			Average 40 miles (65 km)	
Continental slope	Located between shelf and floor, steep slope, is edge of continent			
Continental Rise				
Ocean Basin-- Abyssal Plain				flatter than any land area

Answer

Is the width of the shelf the same in all areas?

Which area is the deepest?

Which area is the most flat?, the steepest?

Which area looks like the land it touches?

Which area is part of the continent?

TOPIC TWO--THE SHAPE OF IT!

THE OCEAN FLOOR

Look--
At features of the ocean floor.

Read--
Topography of the ocean floor.

Construct--
A clay model of the ocean floor showing the features of the continental slope, shelf, rise and abyssal plain.

Demonstrate--
How water covers the features of the ocean floor by submerging the model you constructed in a glass container of water.

Draw, paint and construct--
A mural of the floor of the Gulf of Mexico.

Read and participate--
In the Exploring Terra Activity.

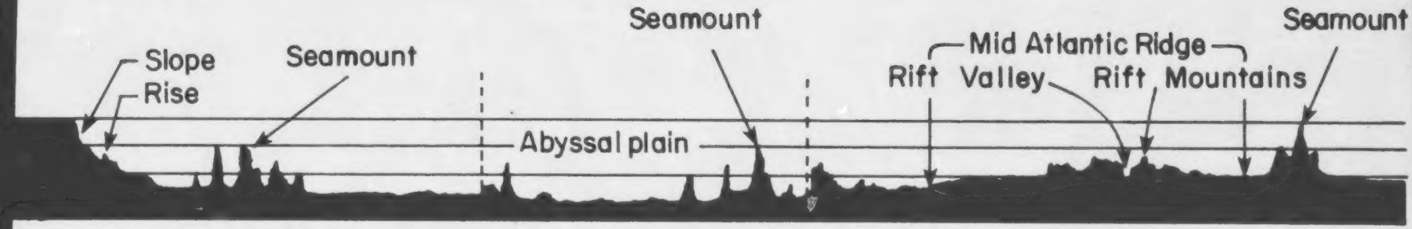
Write--
A story or report or conduct an interview of the Terranaut's experiences on Terra upon his return to the undersea world.

Optional

Report--
On instruments and machines we use to study the oceans.

Read--
Article on exploration and study of the ocean floor.

Report--
To the class on the article you read.


Seamount
Seamount
Slope
Seamount
Rise
Mid Atlantic Ridge
Rift
Valley
Rift
Mountains
Abyssal plain

Features of Ocean Floor

TOPOGRAPHY OF THE OCEAN FLOOR

The northern hemisphere is sometimes referred to as the "land hemisphere", because north of the equator the oceans and seas cover only about 60 percent of the earth's surface. In the southern hemisphere over 80 percent is covered by water.

The picture of the topography of the ocean floor has been developed as the result of studies since World War II. Even today we know only as much about the ocean floor as was known about the United States at the time of the Lewis and Clark expedition into the territory of the Louisiana Purchase.

The edges of the continents lie flooded beneath the ocean. This area is the continental shelf which has an average width of 65 km (40 miles) but there are many variations. Along the western coast of South America, the shelf is missing or only a few kilometers in width. The shelf reaches out 240 kilometers off Florida and from 1,200 to 1,300 km off the arctic coasts of Europe and Russia. This shallow area has an average depth of about 130 m (425 ft.). The topography of the shelf is like that of the adjacent land. If the coastal area is rugged so is the shelf and where the coastal area has low hills or plains so does the shelf. The shelf will also have mineral deposits similar to adjacent land.

Generally, the shelves slope gently toward the ocean basin until they abruptly end at the steeper continental slopes. The continental slope is the edge of the continents. Here the sea floor becomes abruptly steeper, steeper than the mountain ranges on land. The width of the slope is usually between 10 and 20 miles. The slopes drop to an average depth of 12,000 feet. They go miles deeper when they merge with the sides of the deeper trenches.

Spectacular submarine canyons cut into the continental slopes. Some canyons appear to be extensions of the valleys on land and others have no association with valleys. The origin of the canyons is still being debated. If one followed a canyon to the edge of the continental slope, one would see a large, featureless apron sloping very gently seaward. These aprons unite to form a thick sediment deposit, the continental rise. In most cases the sediment cover buries the preexisting bottom features, forming a nearly featureless area.

The continental rises grade into the deep ocean floor or in other areas (around Pacific Ocean) the continental slopes lead directly into the deep trenches of the ocean floor. Most of the ocean basin floor which begins at the foot of the continental slopes lies a depth of two and a half miles or more. In general, large areas of the floors have been buried by sediments to form the abyssal plains. These plains are flatter than any plains on land.

The mid-oceanic ridges are great undersea mountain ranges characterized by earthquakes and volcanic eruptions. They form a more or less continuous chain of mountains 40,000 miles in length with a total area equal to that of all the continents. They rise steeply from the ocean floor and in some places the peaks are above the sea surface forming ocean islands. They split every ocean basin into 2 or more smaller basins. The best known mid-oceanic ridge is the 1,000 mile wide and 10,000 mile long Mid-Atlantic Ridge. A striking feature of the ridge is a "rift valley" or depression that runs along the length of the ridge near the center. The rift may be as deep as 2 miles and up to 30 miles wide. The rift is a zone where sea floor spreading is occurring.

Dotting the ocean floor are drowned, isolated, steep-sloped peaks called seamounts. Most seamounts are at least 1,000 m above the surrounding ocean with sharp peaks and are of volcanic origin. Some peaks have flat tops and are called tablemounts or guyots. Guyots are thought to be volcanic cones whose taps have been cut off by wave action. The guyots then sank beneath the sea or they were drowned by a rise in the sea level.

In some areas the continental slopes lead directly down into deep trenches. The trenches are believed to result from a downward movement of the crust. These narrow, steep-sided depressions contain the greatest depths in the ocean reaching to a depth of 37,782 feet in the Mindanao Trench.

If oil is found under a land area why would one expect to find oil in the adjacent continental slope?

What features are found in the ocean basins but not in the Gulf of Mexico?

Distinguish between a seamount and a guyot.

MURAL OF THE OCEAN FLOOR

Prepare a sea floor mural. Use paper which can be hung on the classroom wall. Your group will be responsible for a section of the mural. The sections of the mural are: beach, continental shelf, continental rise, continental slope, abyssal plain, mid-oceanic ridges, other features (seamounts, guyots, islands) and submersibles. You will be assigned a section.

Draw your section of the mural to scale showing depth. You will have to work closely with the other groups since your sections of the mural must fit together with their section. The plants and animals will be added later. If your group is responsible for the submersibles section, you will sketch submersibles and place them on the mural at the depth to which they can descend.

The section that I am responsible for is ____________________.
Things that need to be included in this section are:

Make sketches or plans for your section below:

EXPLORING TERRA

Imagine the following situation. Man has always lived in the oceans. His body is designed for breathing, working, moving and living underwater. He can not live out of the water. Through the centuries of living under the sea, man has built his home, cities, factories, farms , etc., all underwater. He has developed vehicles from moving people and goods from one underwater city to another. Until the 1970's man has never explored or seen the environment above the water surface or the area of land between the bodies of water. He has named the alien area between the bodies of water Terra.

However, now he has developed the use of most of the space of the ocean environment. He is looking for a new area into which he can expand or colonize. The two areas he knows of are Terra and the environment above the water. He is especially interested in learning about Terra.

Scientists have developed the technology to launch a craft through the surface of the water to probe and sample the surface of the area known as Terra. The first probe is ready to be launched. To determine what information or picture they obtain of terra , place a map of the United States and Texas on the floor. The first probe is designed to land on Terra in the area we know as Texas. Have the student who is to launch the probe (one inch square piece of paper) stand on a chair and drop the piece of paper on the Texas map. Where the paper lands, will be the area the probe lands. What is the area like around where the probe lands? If you are not sure use the Texas Almanac to look up the county for a general description. (Is it flat. mountainous, hilly , etc.? What type of vegetation and animals would the probe see? What is the temperature range?) Remember that there has been no man living on the face of Terra so there will be no man-made features. Describe the area.

Discuss the accuracy of this description of Terra.

Discuss the effect of the time of the year or the time of the day would have on the photographs the probe would send back .

To verify their findings, over the next year, ten more probes were launched to sample and photograph the area where they landed. Have the students drop 10 pieces of paper on the map of the United States and describe the area where each probe lands.

Did any of the probes land on mountains _____, hills _____, plateaus _____, plains _____. forests _____, grasslands _____, marsh _____, desert _____, lakes _____, rivers_____, swamps _____, others _____.
Discuss the accuracy of the description of Terra from the ten probes landing on the area we know as the United States

Suppose that a probe landed during a thunderstorm . What description would it send back?

What must the scientists do to get a better description?

Eventually the scientists hope to land man on terra. They have designed a Terra landing craft and a Terra suit for man. Discuss the problems of a man who can only live and breathe in water trying to live and breathe on land. (Remember to consider factors like climate, weather, moving on land, coping with gravity, altitude, soil surface, etc.)

Describe the design and features the Terra suit for man's survival on land must have.

Select an area of the United States you know well and write a short story, report or an interview of the Terranaut as he returns to the undersea country to report on his experiences. Remember he finds no man-made structures only, only the land, plants, animals and weather of the area.

TOPIC THREE
GEOLOGY OF THE GULF

ACTIVITY ONE--Drifting Continents and Prehistoric Organisms
ACTIVITY TWO--Texas Gulf Coast--Geological Past
ACTIVITY THREE--Texas Gulf Coast-Recent

Materials for Classroom Use:

- Marine Geology/Reading
- Continental Puzzle/Drawing
- Questions
- The Puzzle/Reading
- Plate Tectonics or Sea Floor Spreading/Reading
- Cretaceous Sea Floor and Permian Reef/Drawing
- Prehistoric Organisms/Drawing
- Mesozoic Era/Drawing
- Jurassic Period/Drawing
- Texas Fossils/Drawing
- Prehistoric Marine Organisms/Reading
- Texas Coast in the Geological Past/Series of Drawings
  - Lower Createaceous
  - Upper Createaceous
  - Lower Eocene
  - Middle Eocene
  - Miocene
  - Pleistocene
  - Today
  - Geologic Map of Texas
- Where was the Texas Coast in the Past?/Activity
- Texas Gulf Coast--Pleistocene to Recent/Reading
- A Geological Detective Story/Reading
- Geology of the Gulf of Mexico/Reading
- Salt Domes of the Gulf of Mexico/Map
- Features of the Gulf Coast/Reading
- Types of Coasts of the Gulf of Mexico/Drawing
- Find the Features/Activity
- Changing Coastlines in Historic Times/Reading
- Beach of Matagorda Before and After Hurricane Carla/Drawing
- Growth of Birdfoot Delta/Drawing
- Growth of the Delta of the Colorado/Drawing
- Trouble in Paradise/Reading

Major Objectives for the Topic:

After completing the topic the student will be able to:

1.1 Locate on a map and identify the different features of the Gulf Coast;

1.1 Identify the different types of coastline along the Gulf of Mexico;
1.2 Formulate possible explanations of the geology of the Gulf and the salt domes;
2.2 Describe several prehistoric marine organisms;
2.2 Cite evidence for plate tectonics or sea-floor spreading;
2.2 Cite evidence for and describe changes in the location of the Texas Gulf coast in the geologic past;
2.2 Describe how the coastal area has changed and can change in historic time;
3.1 Describe how our knowledge of marine geology has changed and the reasons for its change;
3.4 Formulate possible ways in which man has and can affect the coastline;
4.2 Analyze factors man should consider in his relationship with the coast.

Teaching Suggestions:

The purpose of this activity is to present information to the student on marine geology, the geology of the Texas coast, the Gulf of Mexico and changes in the coastline.

1. The reading Marine Geology can introduce the students to the topic and information that is known. The Puzzle pieces of the continents will help them to understand the evidence for Plate Tectonics. This resource unit does not include a large number of activities in this area since sets of excellent materials on sea-floor spreading, continental drift and plate tectonics are available. These were produced by the Crustal Evolution Education Project (CEEP) by the National Association of Geology Teachers with support from the National Science Foundation. The modules were developed by teams of science educators, classroom teachers (over 200) and scientists in six writing centers across the United States. The modules (1-3 45 minute periods in length) which are directly related to the ocean are listed below:

Spreading Sea Floors and Fractured Ridges
What Happens when Continents Collide?
Lithospheric Plates and Ocean Basin Topography
How Fast is the Ocean Floor Moving?
Microfossils, Sediments, and Sea-floor Spreading
How does Heat Flow Vary in the Ocean Floor?
Deep Sea Trenches and Radioactive Waste
A Sea-floor Mystery: Mapping Polarity Reversals
Continents and Ocean Basins: Floaters and Sinkers
Plotting the Shape of the Ocean Floor
The Rise and Fall of the Bering Land Bridge
Why does Sea Level Change?

For additional information write:

CEEP Project
Ward's Natural Science Establishment, Inc.
P.O. Box 1712
Rochester, New York 14603
(716) 465-8400

2. Prehistoric Marine Organisms is only an introduction to this subject. The students use the library and collect additional information and prepare dioramas of the organisms in their environment.

3. The maps of Texas coast in the Geologic Map can be used to help the students understand the formation of much of Texas and the Gulf coastal Plain and why Texas has numerous oil and gas fields in the ares which were once part of the coast. A Geological Detective Story and Geology of the Gulf of Mexico will point out the limits of knowledge and understanding of the geologic past. A Geological Highway Map of Texas is an excellent help, especially the cross-sections. It is available from: American Association of Petroleum Geologists, P.O. Box 979, Tulsa, Oklahoma 74101.

4. The Texas Gulf Coast--Recent activities will help students identify and understand features of the Texas Coast and processes that are occuring. If you live in the coastal area you may have the students identify local coast or beach areas which man has affected and how man-made structures have interacted with the natural processes. Include groins, jetties, sea walls, dredging, filling in areas and also upstream interactions.

5. Topic Five, Activity Two and Topic Ten, Activities One and Two have activities and information on man's changing the coastal area and natural changes.

6. Additional Reference: Texas Parks & Wildlife Magazine, Vol. 37, No. 7 (July 1979), "Texas Sea Monsters," p 16-19.

TOPIC THREE--GEOLOGY OF THE GULF
DRIFTING CONTINENTS AND PREHISTORIC ORGANISMS

Read and Discuss--

Marine Geology

Look At--

Five Continental Pieces

Cut Out--

The five pieces and arrange them in various combinations until they fit together in the best arrangement with the fewest gaps or overlaps. Then glue them together in that arrangement on a piece of paper.

Answer and Discuss--

The questions.

Read and Discuss--

The Puzzle
Plate Tectonics or Sea-Floor Spreading

Look At--

Cretaceous: Sea Floor
Permian Reef
Prehistoric Organisms
Mesozoic Era
Jurassic Period
Texas Fossils

Read and Discuss--

Prehistoric Marine Organisms

Make--

A diorama of some prehistoric animals in the environment in which they lived.

MARINE GEOLOGY

In the eighteenth century, geologists found that most of the sedimentary rocks on the continents had been deposited in the oceans of the past. However, it wasn't until the middle of the twentieth century that geologists began to study the geology of the oceans. First they began to try to explain the origin of the marine sedimentary rocks and to try to trace the history of the oceans during the long geological past. Quite suddenly in the 1960's most of the ideas about the development of the earth were revised. New ideas about the continents splitting apart and forming the oceans were developed. With this idea many of the puzzles of geological history began to make sense. The old ideas have been discarded. The new ideas have occurred because geologists finally decided to look at the oceans and find out what was under the unexplored 72% of the earth's surface.

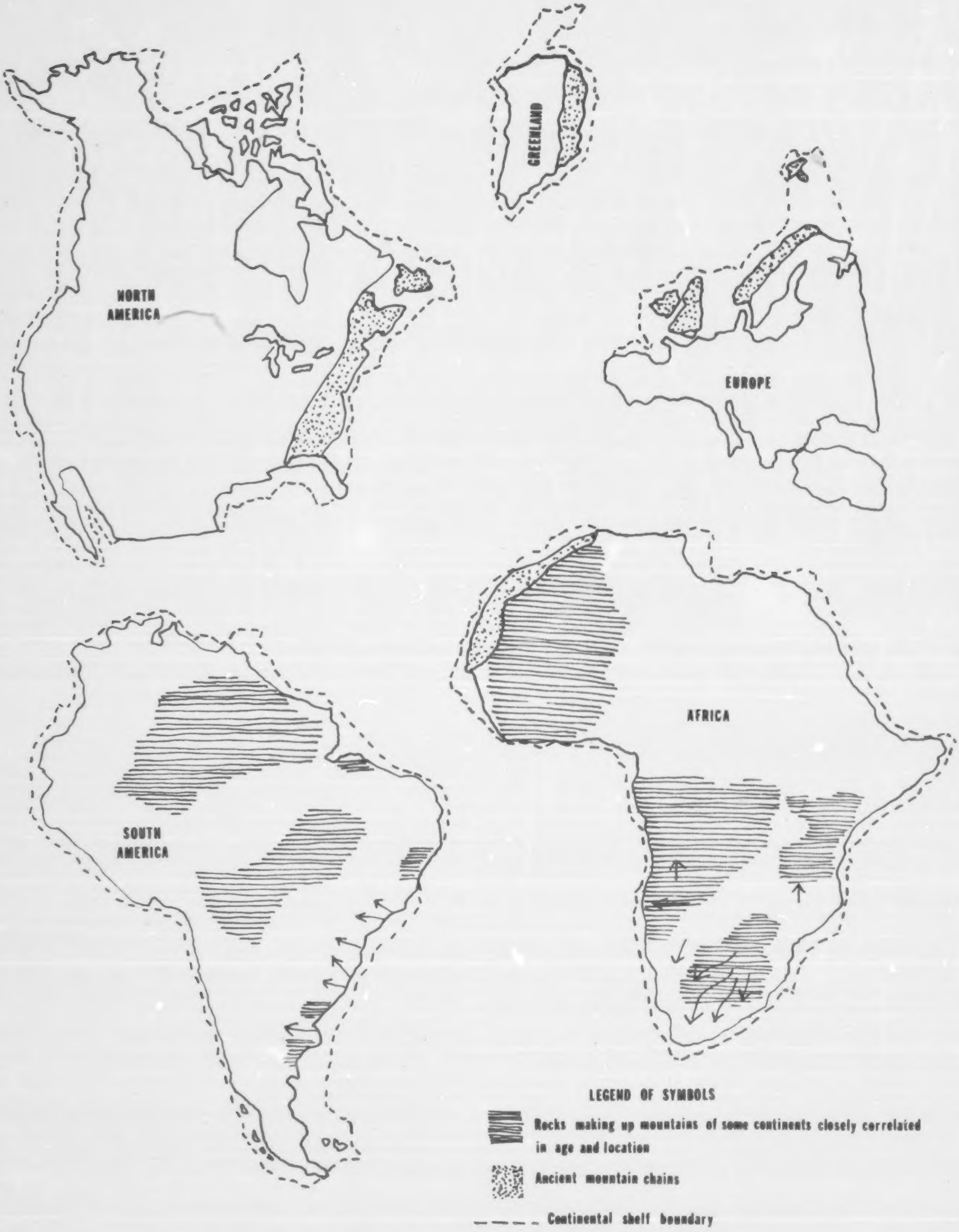
Before World War I, marine geology was almost unknown. If you look at old textbooks, they show that most of the ocean floor was flat like the Great Plains. In 1920, echo soundings were invented and this allowed scientists to make continuous profiles of the sea floor without stopping the ship. The results showed that the ocean floor was not flat but rugged.

It was also believed that ocean sediments should be coarse grained near the shore and fine grained farther from the land. However they found that the sediments away from the shore were more coarse. Many other discoveries soon followed. The development of underwater photography using cameras lowered to the bottom, showed that the sea floor processes were much more active in deep water than previously believed. They also began to use geophysical methods to study the sea floor. These methods included measuring gravity; heat measurements from probes stuck in the bottom; measuring the magnetism of the sea floor. All these methods gave us startling new knowledge about the ocean floor.

In 1945, Auguste Piccard built the bathyscaphe. It was an oil-filled sea-going diving balloon with a diving bell attached and made the first dives to the ocean floor. Jacques Cousteau soon followed with his remarkable explorations in the Diving Saucer. Other deep diving vehicles were developed so now the geologist could look at the features which before he had only known about through the use of instruments. Also during World War II, the development of scuba diving by Cousteau and Emile Gagnan allowed many geologists to observe the shallow ocean floors themselves.

Ocean floor drilling has given us a vast fund of information. This has led to the discovery of old sunken land masses, reversals of the earth's magnetism and uncovered unique fossils. It has demonstrated that the crust under the oceans has been sliding actively under the continents. They have also found that there are no ocean sediments as old as the earliest marine sediments found in the continents.

World War II also provided many scientific developments which increased the knowledge of the ocean floor. In using different sound frequencies to locate submarines, scientists found that low frequencies would send sound waves through the sediments of the sea floor and reflect back from the deeply buried layers of rock. Now the rocks beneath the sediments could also be studied. Not only did science benefit but industry did also in the search for new energy sources. Many oil fields under the ocean floor were discovered as a result of surveys with underwater sound. Even though we have learned much about the ocean floor even today we only know as much about the land under the ocean floor as was known of the United States at the time of the Lewis and Clark Expedition into the Louisiana Purchase.


GREENLAND
NORTH AMERICA
EUROPE
AFRICA
SOUTH AMERICA
LEGEND OF SYMBOLS
▤ Rocks making up mountains of some continents closely correlated in age and location
▨ Ancient mountain chains
- - - - Continental shelf boundary
→ Direction of continental glacier
—— Continental boundaries

Questions:

1. Which areas of your continental puzzle match the closest with the areas adjacent to them?

2. Do any of the glacial marks seem to indicate the movement of glaciers from one land mass to another?

3. What land masses seem to be closely related using zones of ancient mountain chains to relate them to each other?

4. Where do zones of rock with similar ages and mineral content seem to indicate the close matching of continents?

5. Where are there areas where gaps exist in your puzzle?

   How could you explain where this material has gone?

6. Where are there areas where the continents overlap?

   How could you explain what might happen in these areas?

7. Using physical maps of the world and the ocean floors, suggest as many ways as you can think of in which scientist might continue to search for additional clues to help us solve the continental puzzle.

THE PUZZLE

In 1912, Alfred Wegener, an Austrian meteorologist published a book in German called The Origin of the Continents and Oceans. In it, he stated that in the Paleozoic and early Mesozoic eras there was an ancient continent called Pangaea. This continent included all the land area of the earth. He also stated that about 135 million years ago this huge continent broke apart and the pieces of North and South America drifted west. This left the Atlantic Ocean as the gap.

Wegener's arguments were: the two sides of the Atlantic appear to fit together; glaciated lands that are now found in the tropics were once around the south pole; fossils of the same age can be matched between the two sides of the Atlantic. He also pointed out that the mountain rages that appear to end abruptly at the continental margins could be fitted together where the continents were once connected.

However, many scientists refused to accept the idea. Their question was: "How could a great continent move like a ship over the solid earth's interior, especially for thousands of miles?" The fit of the two sides of the atlantic was denied or called a coincidence. The fossil similarities on the two sides were explained by the organisms migrating across the northern areas where only narrow seas separated the continents.

As petroleum geologists made investigations of the continents, many more began to accept the idea of drifting continents. Most geologists did not accept the idea because of many unanswered questions. In the 1960's two seagoing American geologists, Harry Hess and Robert Dietz at about the same time suggested a new idea. Deitz called it Sea-Floor Spreading. The new discovery of the mid-Atlantic ridge led to this concept. This theory has some differences from the Wegener hypothesis. The Sea Floor Spreading idea fits better with the new discoveries.

Today with the finding of smaller plates and because of the complications of their movements a new name is used for the hypothesis. It is now called plate tectonics. Many scientists favor the plate tectonics concept. However, some geologists still oppose it. Some of their arguments sound convincing. Yet despite its attractive features, plate tectonics has many things to explain. It is hard to understand how continents and ocean floors can wander so rapidly over the earth. One should keep an open mind and see what science will tell us in the future.

PLATE TECTONICS OR SEA--FLOOR SPREADING

The new hypothesis of sea-floor spreading was that a crack occurred between the continents. Lava flowed into the crack from the molten layer beneath the crust. The lava filled the crack and hardened. Since the cooled lava was heavier than the rocks of the continents on either side it sank lower than the continents. This formed a long narrow sea which was the beginning of the Atlantic Ocean. A new crack formed in the center of the narrow sea, more lava flowed in pulling the continents further apart. Continued cracking and new lava flowing in very slowly produced a wide ocean. The original sides of the crack became the edges of the continent.

The edge of the plate into which the continent is moving is sinking below it. So along the west coast of the Americas we find great faults; earthquakes that begin deep in the earth; deep trenches; rows of volcanoes along the adjoining continents and islands are all the result of the sinking of the Pacific ocean crust beneath the moving American continents.

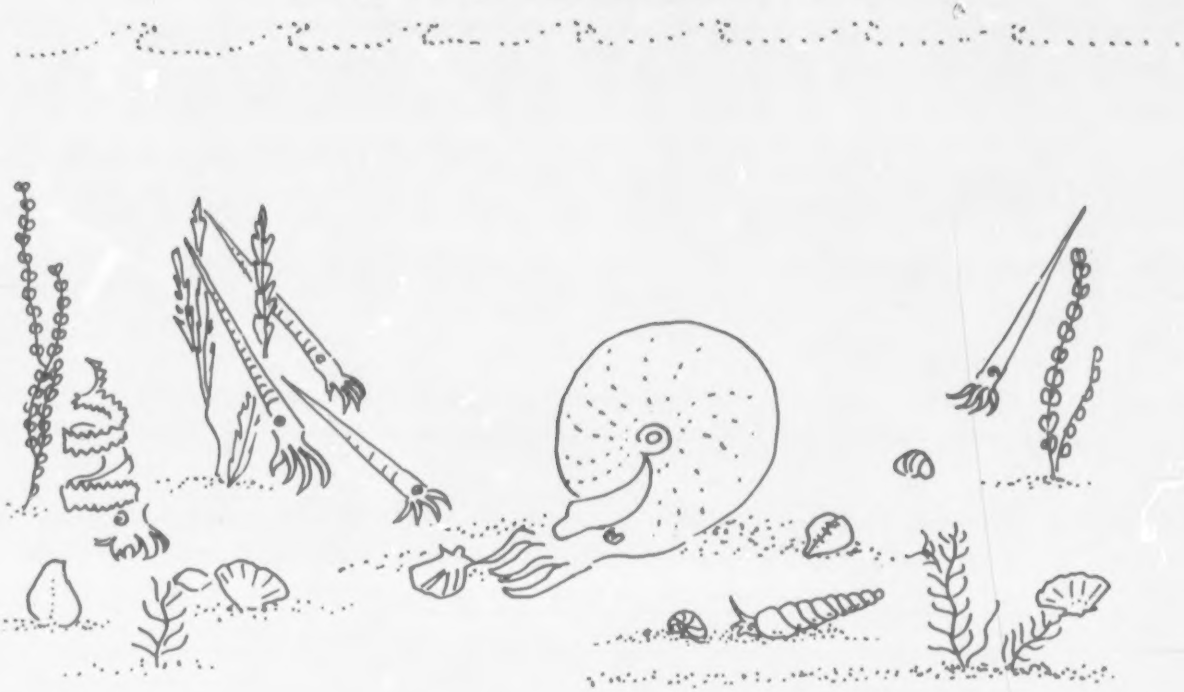
If sea-floor spreading occurs then the lavas should get older further away from the Atlantic ridge. The sediments that cover the lavas should become thicker away from the ridges. The sediment over the lavas should be older further away from the ridge. Deep ocean drilling has indicated that this is true. It has also shown that there are no ocean sediments earlier than the Jurassic. This indicates that the sea-floor spreading occurred since this period.

Using deep-diving vehicles, geologists have gone into one of the rift valleys in the Mid-Atlantic Ridge. (Project FAMOUS-French-American Mid-Ocean Undersea Study) They found evidence of freshly opened cracks and blocks that had been pulled apart recently. They also found fresh lava flows that were still giving off heat. Diving into the Galapagos Rift- a boundary between separating plates of the oceanic crust, they found active hydrothermal vents on the ocean floor.

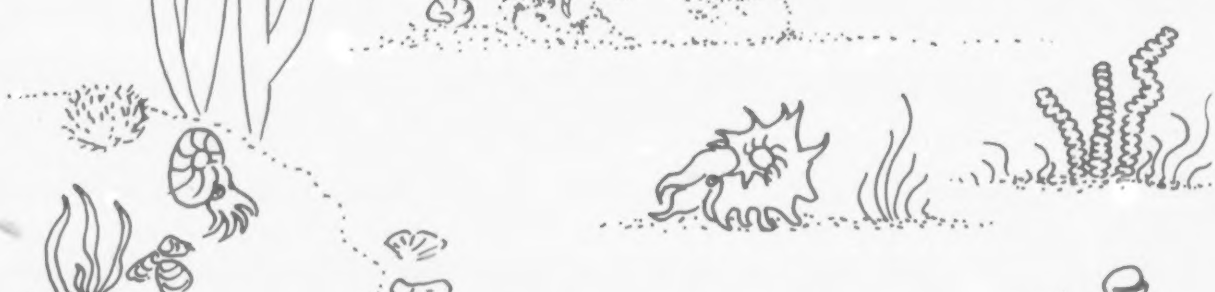
A more complicated type of evidence comes from measuring the magnetism of the rocks underlying the ocean floor. When molten rocks cool, the direction of the magnetism of their grains is oriented toward the north pole. Scientists have found that in the past the earth's magnetic poles have changed. The magnetic poles changed an average of each million years. By measuring the magnetism, it is possible to tell whether the north magnetic pole was in the northern or southern hemisphere when the lava cooled. There should be bands of positive and negative magnetic belts parallel to the Mid-Atlantic ridge if sea-floor spreading hypothesis is true. There should also be positive and negative magnetic belts of the same sequence on each side of the ridge. Scientists have found that these belts do exist in this pattern. The width of each belt tells how fast the sea-floor was spreading. This indicates that there has been enough time to allow the development of the entire Atlantic. It would probably have resulted in every portion of the Pacific crust being subducted. This would explain why we find no old crust under the ocean.

Sea-floor spreading also accounts for the occurence of similar fossils on both sides of the Atlantic, mountain ranges on both sides of the Atlantic whose ends could be fit together if the continent were not separated. Ancient glaciers which appeared to be coming out of the ocean can also be explained by the former connected land masses that now have separated by sea-floor spreading.

CRETACEOUS SEA FLOOR

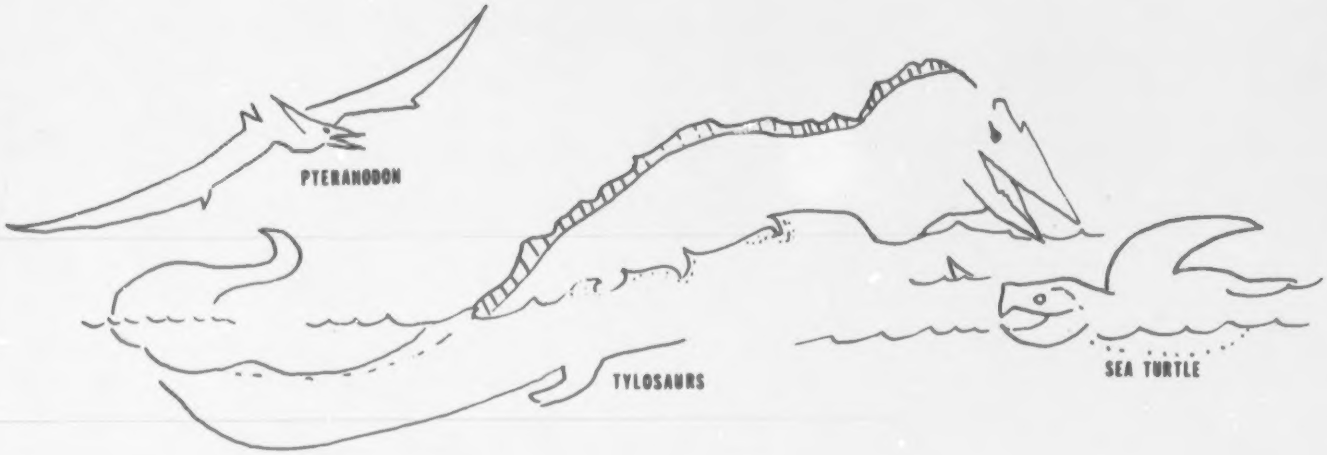


PERMIAN REEF



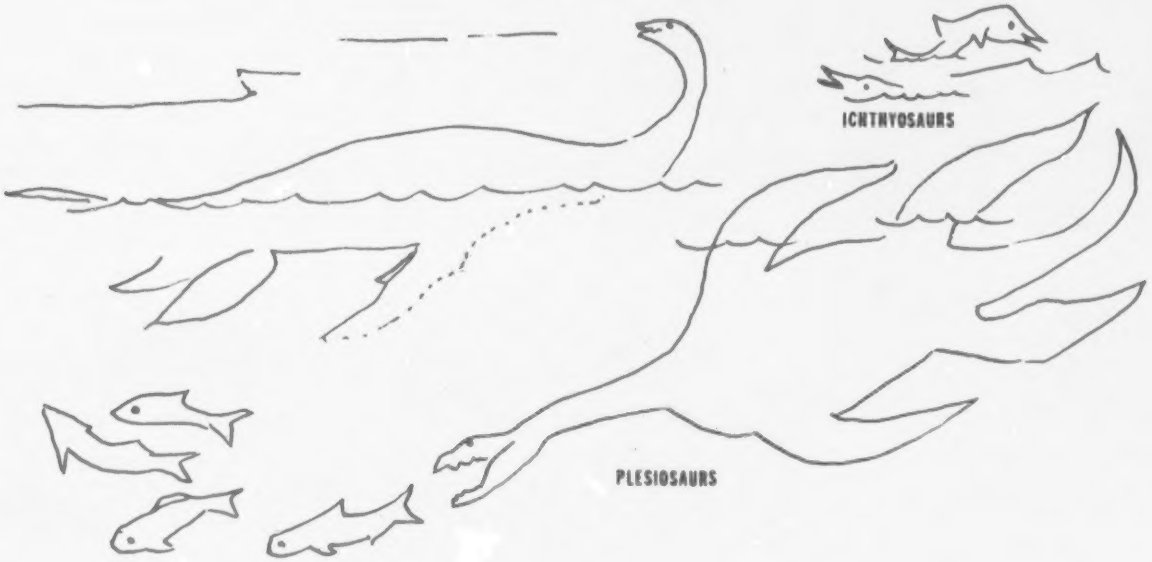
MESOZOIC ERA

100 MILLION YEARS AGO

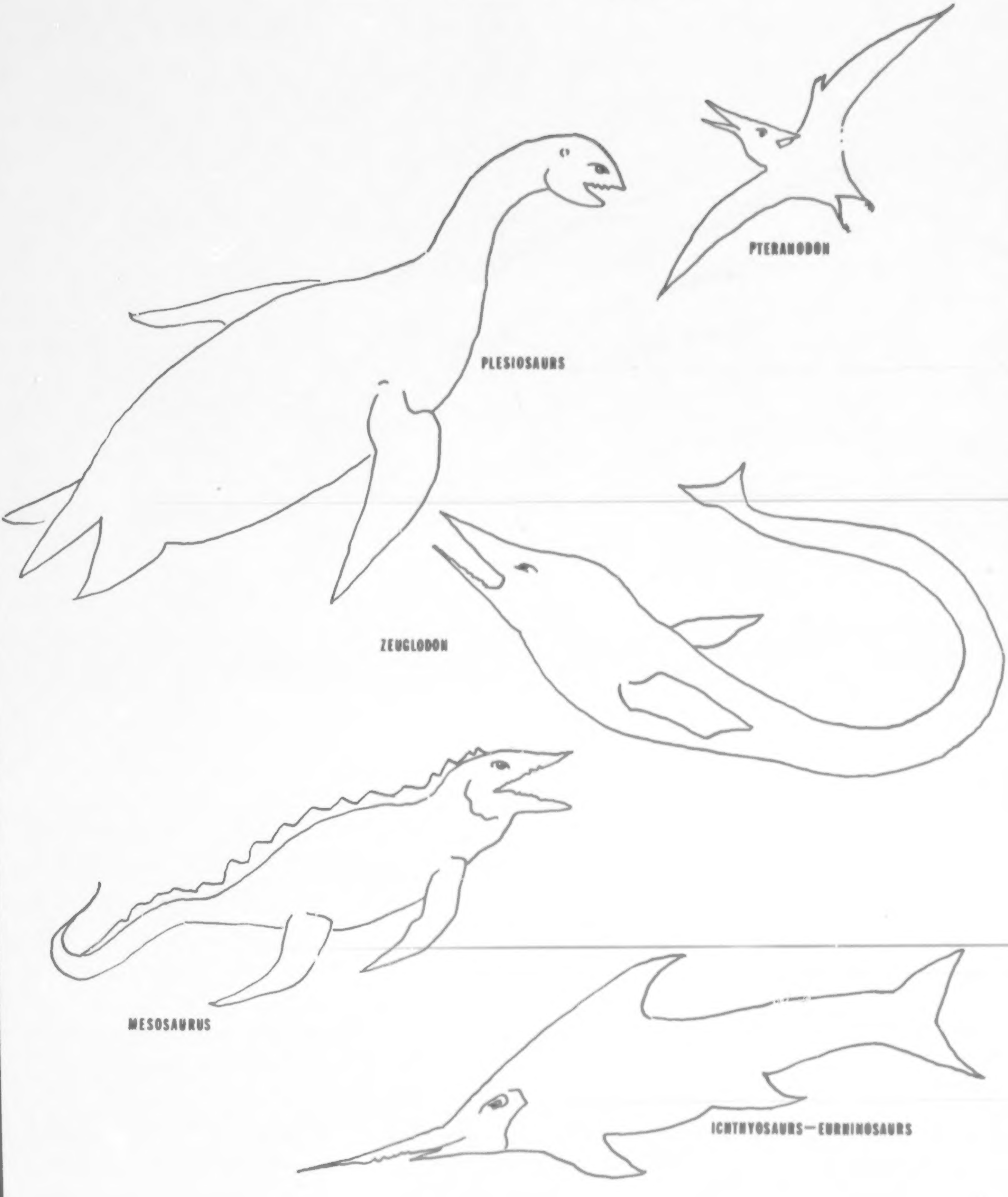

PTERANODON
TYLOSAURS
SEA TURTLE

JURASSIC PERIOD

150 MILLION YEARS AGO

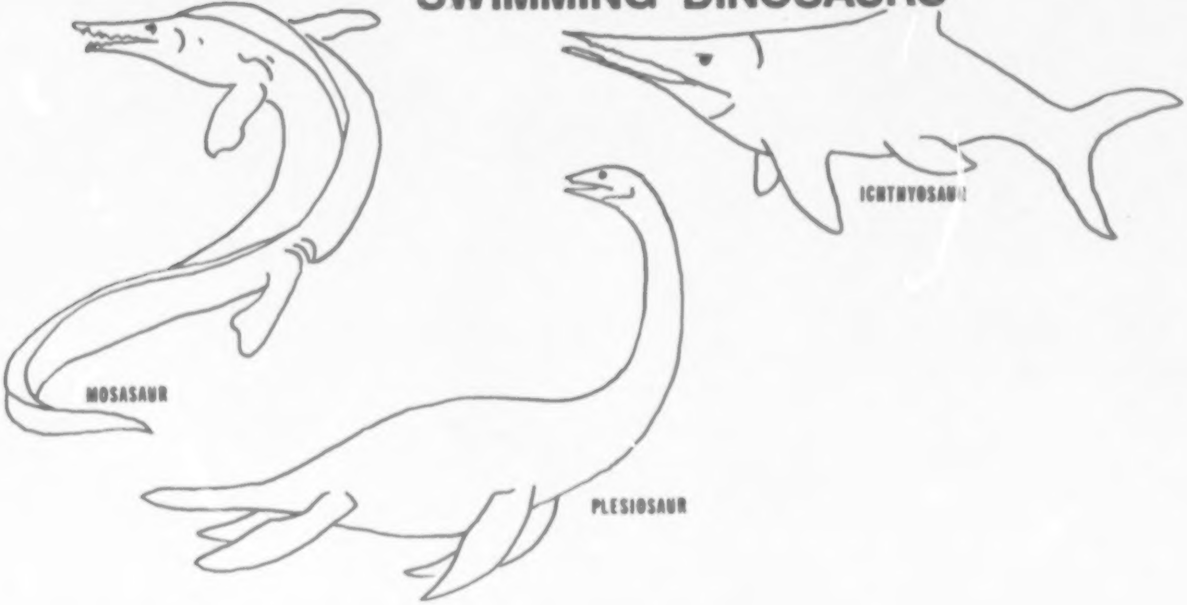

ICHTHYOSAURS
PLESIOSAURS

PREHISTORIC ORGANISMS

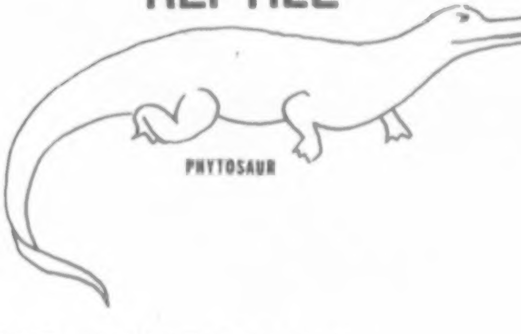

PTERANODON
PLESIOSAURS
ZEUGLODON
MESOSAURUS
ICHTHYOSAURS—EURHINOSAURS

·TEXAS FOSSILS·

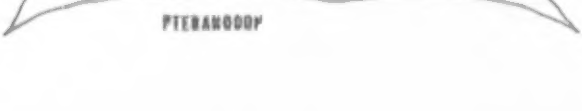
SWIMMING DINOSAURS?

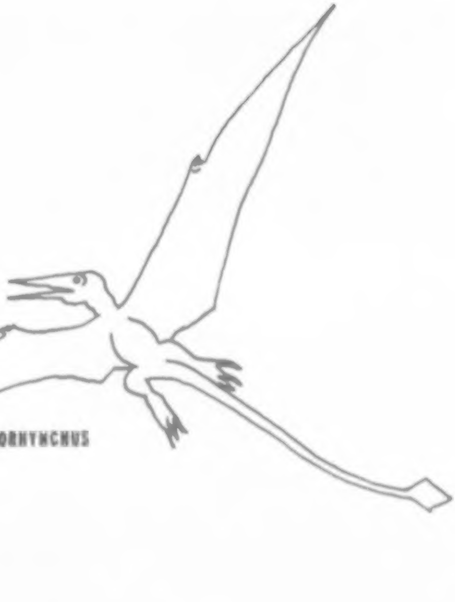

ICHTHYOSAUR
MOSASAUR
PLESIOSAUR

CROCODILE-LIKE REPTILE

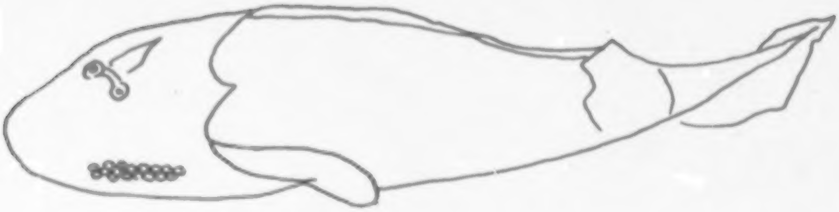


FLYING DINOSAURS

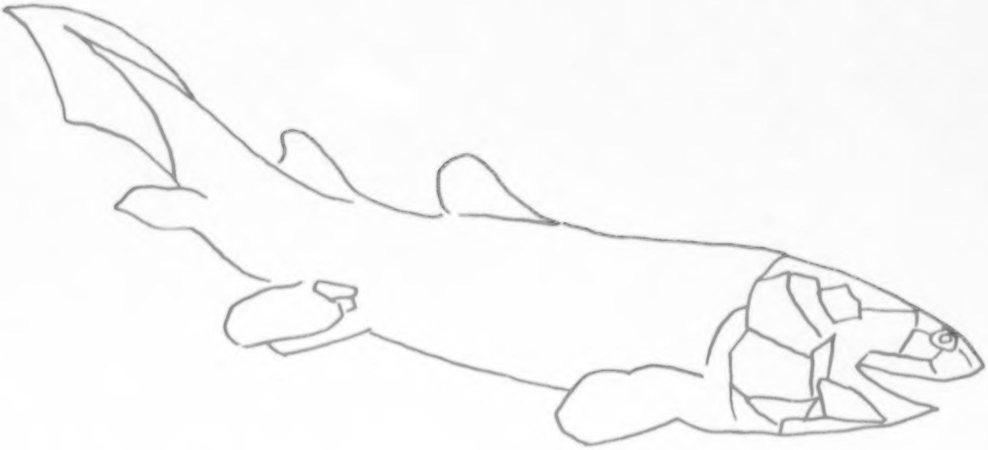

PTERANODON


RHAMPHORHYNCHUS

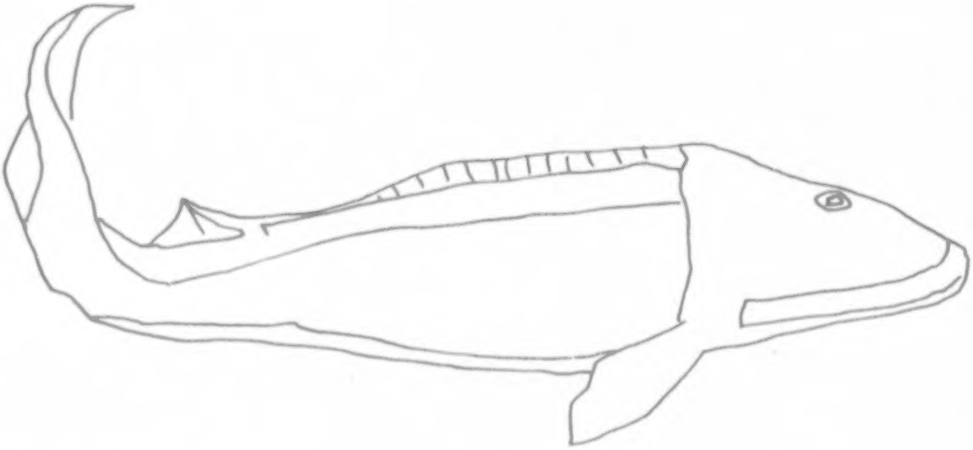
·TEXAS FOSSILS·



PLACODERM



OSTEOLEPIS



HEMICYCLASPIS

PREHISTORIC MARINE ORGANISMS

The origin of life was perhaps the greatest of all events in biology. The processes involved in the event were numerous and extraordinarily complex. The transition from nonliving to living occurred at some point in time before 3.2 billion years ago.

Where did life begin? There are good reasons for thinking that it originated in the sea. The sea contains the salts important to the health and growth of organisms. In addition to providing the nutrients the oceans moderated temperatures, shielded delicate tissue from deadly rays and generally protected life in its feeble beginnings.

Although tracks and burrows presumed to have been made by many-celled animals are found in rocks over a billion years old, fossils showing body form have not been found in rocks older than about 0.7 billion years. The late Precambrium includes evidence of marine algae, radiolarians, worm burrows, sponge spicules, brochiopods, and coelenterates.

An abundance of marine invertebrates is found in the Cambrium period which began 600 million years ago. These include radiolarians, worms, coelenterates (jellyfish), sponges, bryozoans, brachiopods, mollusks, cephalopods, echinoderms, arthropods (trilobites) and many unfamiliar forms none of which have hard shells or skeletons. Toward the end of Palezoic era the giant sea scorpions which grew to a length of 15 feet reached their peak.

In Texas we find that many marine invertebrates were present from the Cambrian to recent in age and are abundant as fossils in the marine formations. Some appeared and then became extinct. Some of the marine invertebrates whose fossil remains we find in marine formations are: foraminifera, radiolarians, sponges, jellyfish, corals, sea anemones, bryozoans, brachiopods, chitons, tusk-shells, gastropods, pelecypods, cephalopods and echinoderms.

We are unable to say precisely when fish began to populate the oceans. We are certain that fish existed at least about 480 million years ago. An example of the oldest fish is the primitive jawless fish Hemicyclaspia that possessed prominent head shields and scales of bone, was toothless and a bottom feeder. The placoderms was a primitive jaw-bearing fish which was shark-like in appearance. They were heavily armored and some of them grew to be as much as 30 feet in length.

It was during the Devonian Period (405 million to 345 million years ago) which is aptly called the "age of fishes" that cartilaginous fishes appeared. These include the sharks, skates and rays, and rat fishes.

COELACANTHS

Shark teeth can be found in Texas from the Pennsylvanian formations to the Miocene rocks. These are probably the most common vertebrate fossils to be found in Texas.

The bony fish, however, are the most numerous, successful and varied of all the aquatic vertebrates. They have adapted themselves to all kinds of water. The bony fish have an internal bony skeleton, well-developed jaws, an air-bladder and typically, an external covering of scales. The remains of bony fish have been collected in many localities in Texas. Osteolepis is one of the early bony fish. Coelancanths were once thought to be extinct since the Cretaceous Period (128 million to 62 million years ago); however, in 1938 and as recently as 1972 living specimens have been captured in the deep water off Madagascar.

The earliest sharks of the genus Pleuracanthus were the large beasts of prey in the waters of the Carboniferous Period (345 to 265 million years ago). These sharks were very abundant and reached a length of 28 inches.

The phytosaurs were a group of crocodile-like reptiles which ranged from 6 to 25 feet in length. They resembled crocodiles both in appearance and where they lived. However they are a separate group from the crocodiles and lived in Texas during the early Mesozoic era (Triassic Period).

In the Permean period (265 to 225 million years ago) there was a peculiar and strange saurian, Mesosaurus. It was not very big,only about 28 inches long. Its skull was elongated and its long jaws had a great number of fine sharp teeth. It is the oldest aquatic reptile. The ichthyosaurs, short-necked marine reptiles that were fish-like in appearance were the most abundant carnivores of the Mesozoic era (225 to 62 million years ago). They resembled modern dolphins and some reached lengths of 25 to 40 feet. The average length was around 7 feet. Well-preserved fossils show they gave birth to live young. Many different species of ichthyosaurs lived in the Mesozoic seas. One of the most interesting was the Eurhinosaurus which had toothed jaws of unequal length. Their upper jaw was almost twice the length of their lower jaw. Although the ichthyosaurs look like fish or dolphins, there is no relation between them. The similiar appearance is only because of a very perfect adaptation to life in water.

The mosasaurs are another group of extinct marine lizards. Some of these great reptiles grew to be as much as 50 feet long and their great gaping jaws were filled with many sharp recurved teeth. They were present in the great Cretaceous (128 to 62 million years ago) seas which covered many parts of Texas.

Also present in these seas were giant turtles, Archelon, which reached a length of 12 feet.

The Plesiosaurs were marine reptiles which had a broad turtle-like body and paddle-like flippers. Some were long-necked with small heads and long tails; others were short-necked and long-headed. They ranged in length from 15 to 40 feet. These reptiles were not as streamlined or well equipped for swimming as the ichthyosaurs or mosaurs, but the long serpent-like neck with a small head with a mouth full of sharp teeth. It was probably very useful in helping catch the other small animals for food. They were found in Texas during the Cretaceous period too. Ichthyosaurs and plesiosaurs were the carnivorous masters of the oceans. Hosts of ammonites (some up to 6 feet in diameter) were in the seas together with gastropods, pelecypods, squids, echinoids, crinoids and foraminifera.

The Pterosaurs were the Mesozoic reptiles with bat-like wings supported by arms and long thin "fingers". The huge Pteranodon with a wing-span of more than 26 feet had a large skull which extended to the rear in a long bony comb. The long pointed snout was toothless and excellently adapted to the hunting of fish and molluscs. The life of the Pterandon is compared with the life of the present-day albatross which inhabits the open sea. The Pterandon was a passive flyer moving mainly in gliding flight, like the albatross, which is able to move rapidly in the air without flapping its wings.

The alligators first appeared in the Tertiary while crocodiles first appeared in the Cretaceous. They were much larger and more abundant during Cretaceous and Cenozoic time than they are today. The remains of both are found in Texas, and one such crocodile represents the remains of the largest crocodile discovered. It probably had an overall length of 40 to 50 feet and its massive skull was 6 feet long with exceptionally strong jaws.

In the Eocene are the remains of the extinct whale-like form of *Basilosaicrus* or *Zenglodon*. This marine mammal attained a length of over 40 feet and had a body form that was well adapted to speed and maneuverability in water. The true whales are found in the later marine deposits.

The fossilized remains of the marine organisms help provide us with information about marine life in the past. It provides us some information about when it lived, where it lived and how it lived. They are also important in tracing the development of the plants and animals of our earth. However, we must remember that the fossil record is incomplete.

TOPIC THREE--GEOLOGY OF THE GULF
TEXAS GULF COAST--GEOLOGICAL PAST

Look at--

The Drawings of the Texas Coast in the Geologic Past
- Lower Cretaceous
- Upper Cretaceous
- Lower Eocene
- Middle Eocene
- Miocene
- Pleistocene
- Today
- Geologic Map of Texas

Read and Complete

Where Was the Texas Coast in the Past?

Read--

Texas Gulf Coast--Pleistocene to Recent

Answer--

The questions

Read and Discuss--

A Geological Detective Story

Look at--

Map of Salt Domes of the Gulf Coast

Read and Discuss--

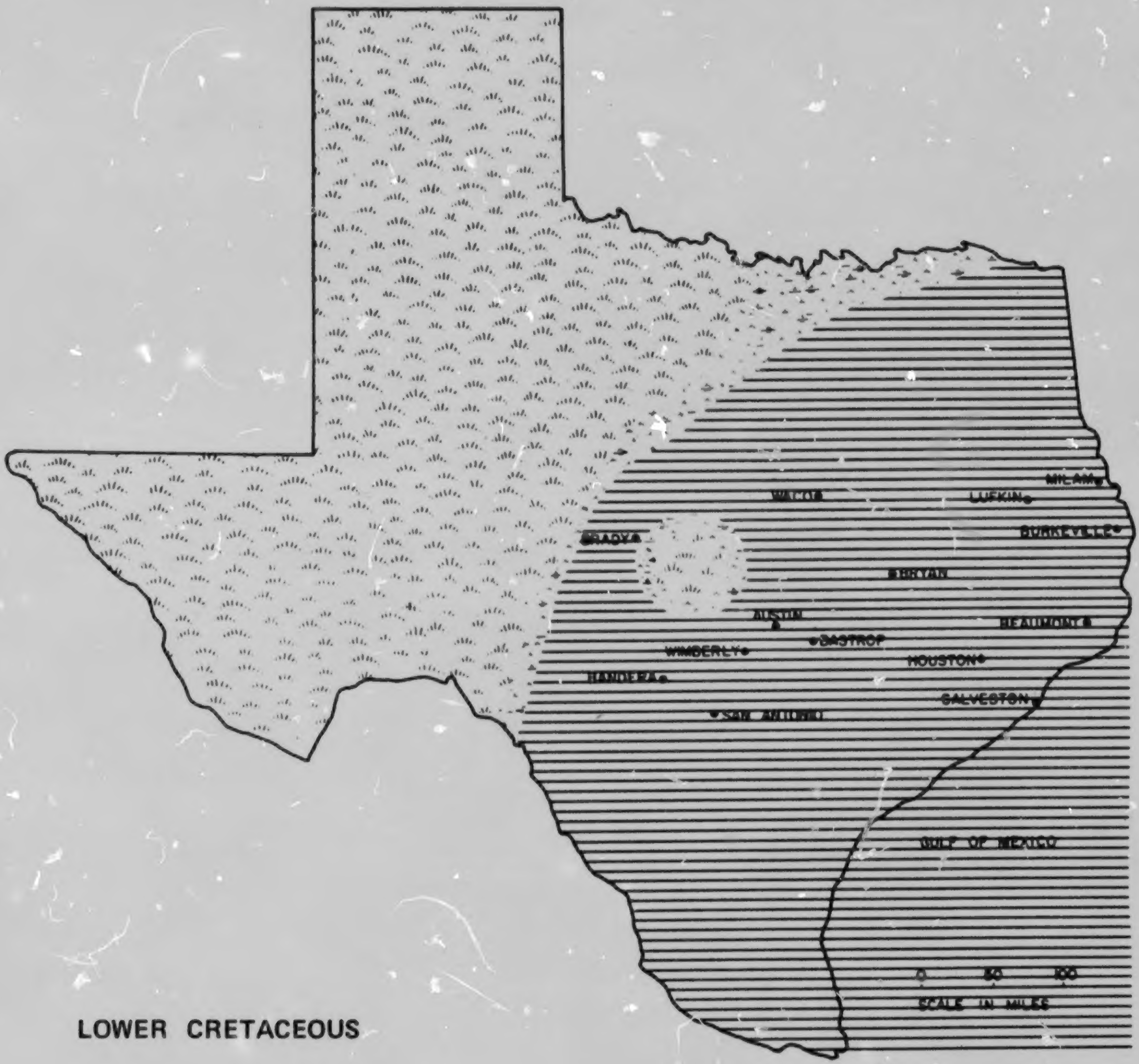
Geology of the Gulf of Mexico

Obtain--

A Geological Highway Map of Texas and look at the Cross Section of the Coast and Gulf of Mexico.

Note--

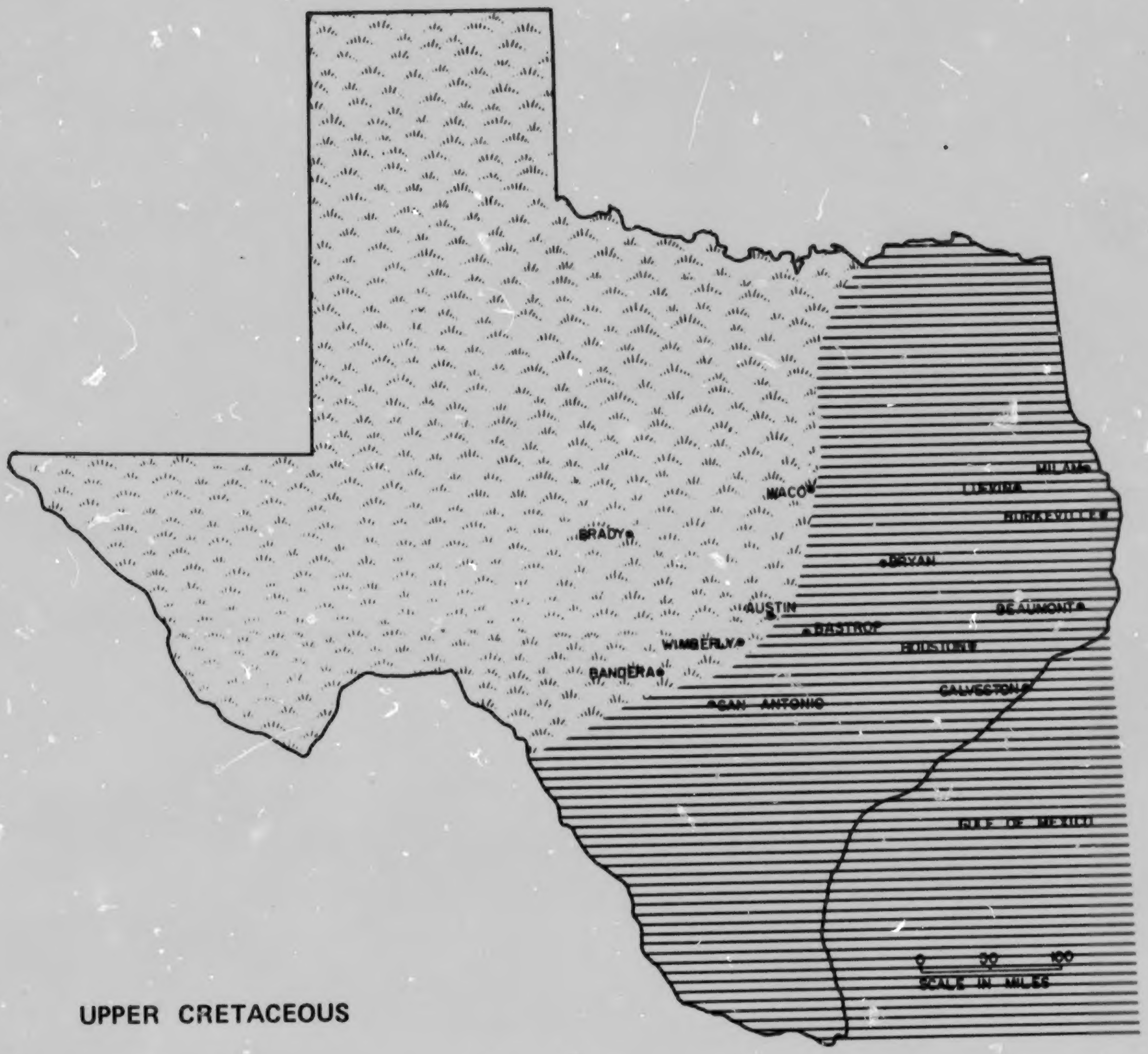
The geosyncline and the salt domes.


WACO
LUFKIN
MILAM
BRADY
BURKEVILLE
BRYAN
AUSTIN
BASTROP
BEAUMONT
WIMBERLY
HOUSTON
BANDERA
GALVESTON
SAN ANTONIO
GULF OF MEXICO
0 50 100
SCALE IN MILES

LOWER CRETACEOUS

LEGEND

- ▨ LAND
- ▨ TRANSITION ZONE - COASTAL BAYS, LAGOONS, MARSHES, DELTAS, BEACHES, ETC.
- ☰ SEA


MILAM
LUFKIN
BURKEVILLE
WACO
BRADY
BRYAN
AUSTIN
BASTROP
BEAUMONT
WIMBERLY
HOUSTON
BANDERA
GALVESTON
SAN ANTONIO
GULF OF MEXICO
0
50
100
SCALE IN MILES

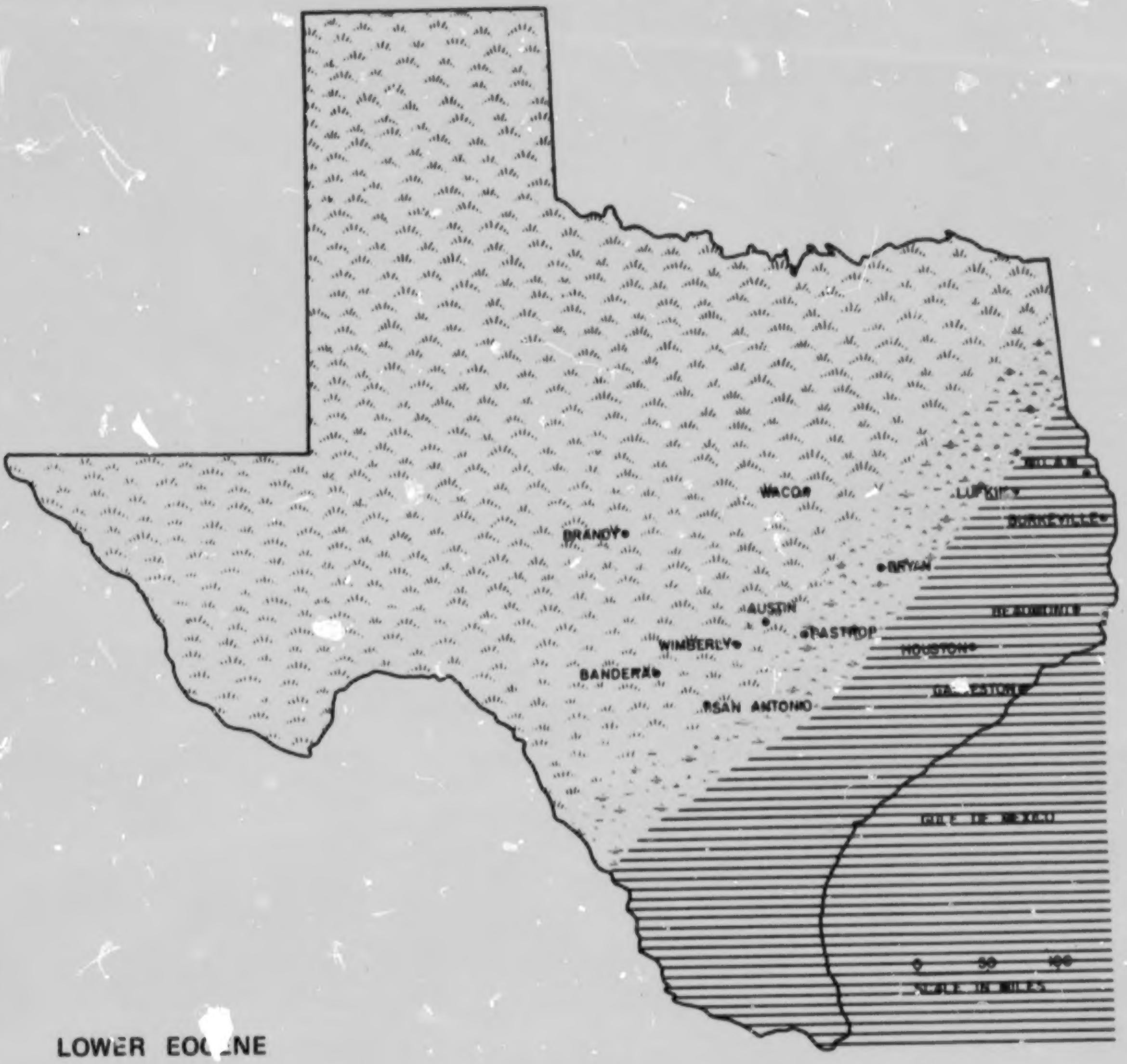
UPPER CRETACEOUS

LEGEND

LAND

TRANSITION ZONE - COASTAL BAYS, LAGOONS, MARSHES, DELTAS, BEACHES, ETC.

SEA


WACO
BRADY
LUFKIN
BURKEVILLE
BRYAN
AUSTIN
BASTROP
WIMBERLY
BANDERA
SAN ANTONIO
BEAUMONT
HOUSTON
GALVESTON
GULF OF MEXICO
0 50 100
SCALE IN MILES

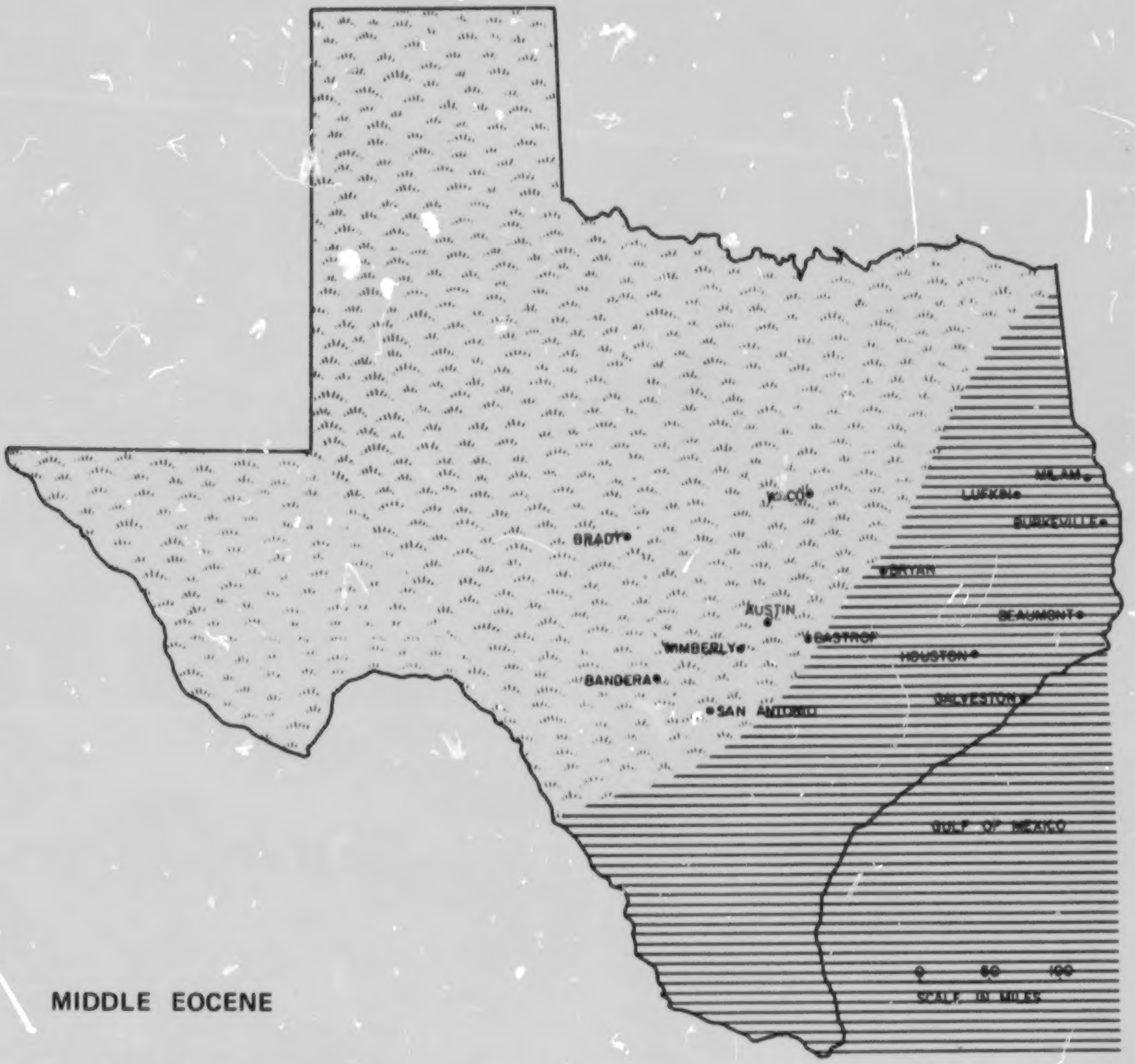
LOWER EOCENE

LEGEND

▨ LAND

▨ TRANSITION ZONE - COASTAL BAYS, LAGOONS, MARSHES, DELTAS, BEACHES, ETC.

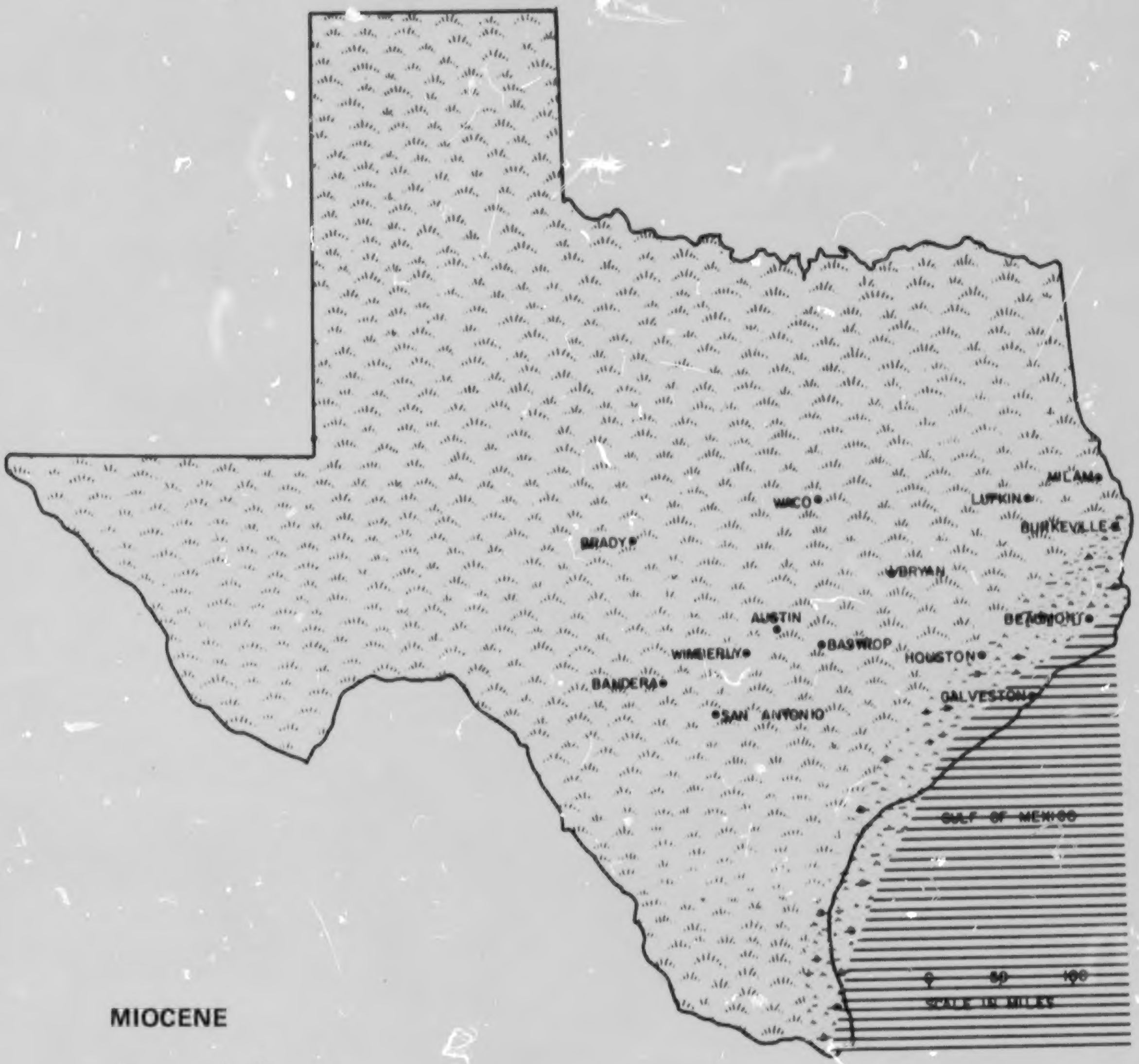
☰ SEA


MILAM
LUFKIN
BURKEVILLE
WACO
BRADY
BRYAN
AUSTIN
BEAUMONT
BASTROP
WIMBERLY
HOUSTON
BANDERA
GALVESTON
SAN ANTONIO
GULF OF MEXICO
0 50 100
SCALE IN MILES

MIDDLE EOCENE

LEGEND

- ▨ LAND
- ▨ TRANSITION ZONE-COASTAL BAYS, LAGOONS, MARSHES, DELTAS, BEACHES, ETC.
- ☰ SEA


MILAM
LUFKIN
WACO
BURKEVILLE
BRADY
BRYAN
AUSTIN
BEAUMONT
WIMBERLEY
BASTROP
HOUSTON
BANDERA
GALVESTON
SAN ANTONIO
GULF OF MEXICO
0
50
100
SCALE IN MILES

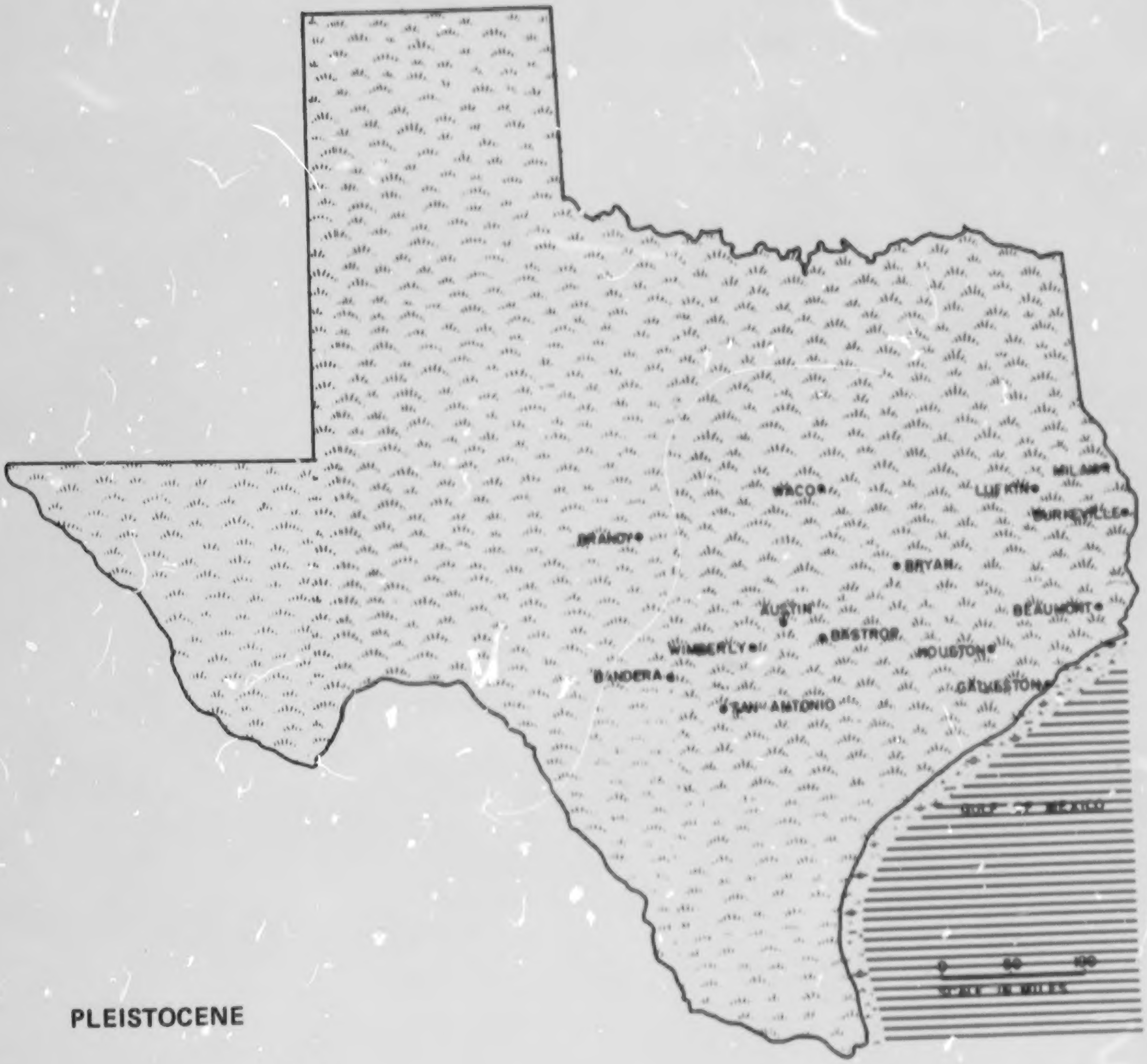
MIOCENE

LEGEND

▨ LAND

▨ TRANSITION ZONE — COASTAL BAYS, LAGOONS, MARSHES, DELTAS, BEACHES, ETC.

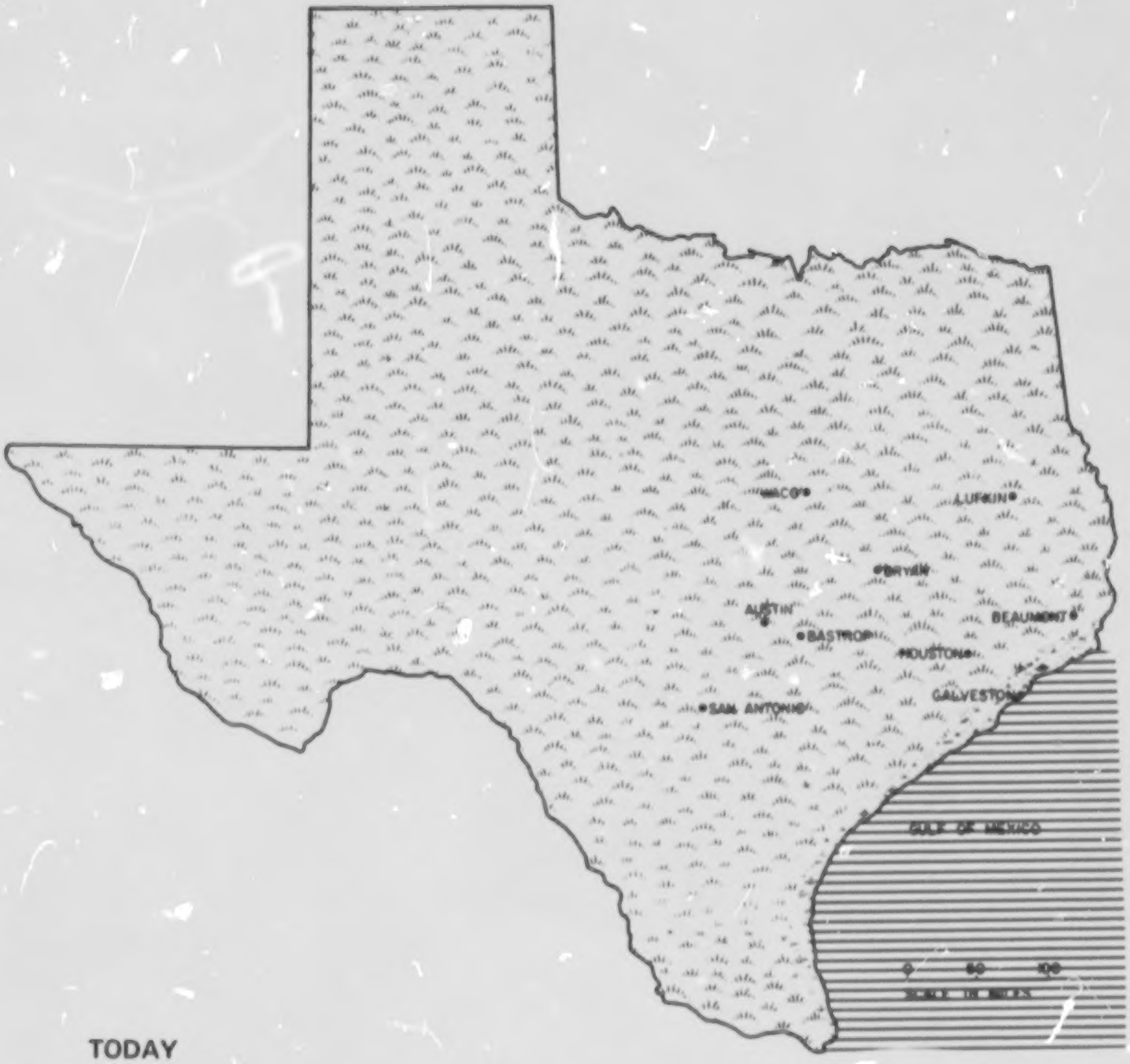
☰ SEA


WACO
LUFKIN
MILAM
BURKEVILLE
BRANDY
BRYAN
AUSTIN
BASTROP
BEAUMONT
WIMBERLY
HOUSTON
BANDERA
GALVESTON
SAN ANTONIO
GULF OF MEXICO
0 50 100
SCALE IN MILES

PLEISTOCENE

LEGEND

- ▨ LAND
- ▨ TRANSITION ZONE – COASTAL BAYS, LAGOONS, MARSHES, DELTAS, BEACHES, ETC.
- ☰ SEA


WACO
LUFKIN
BRYAN
AUSTIN
BASTROP
BEAUMONT
HOUSTON
GALVESTON
SAN ANTONIO
GULF OF MEXICO
0
50
100
SCALE IN MILES

TODAY

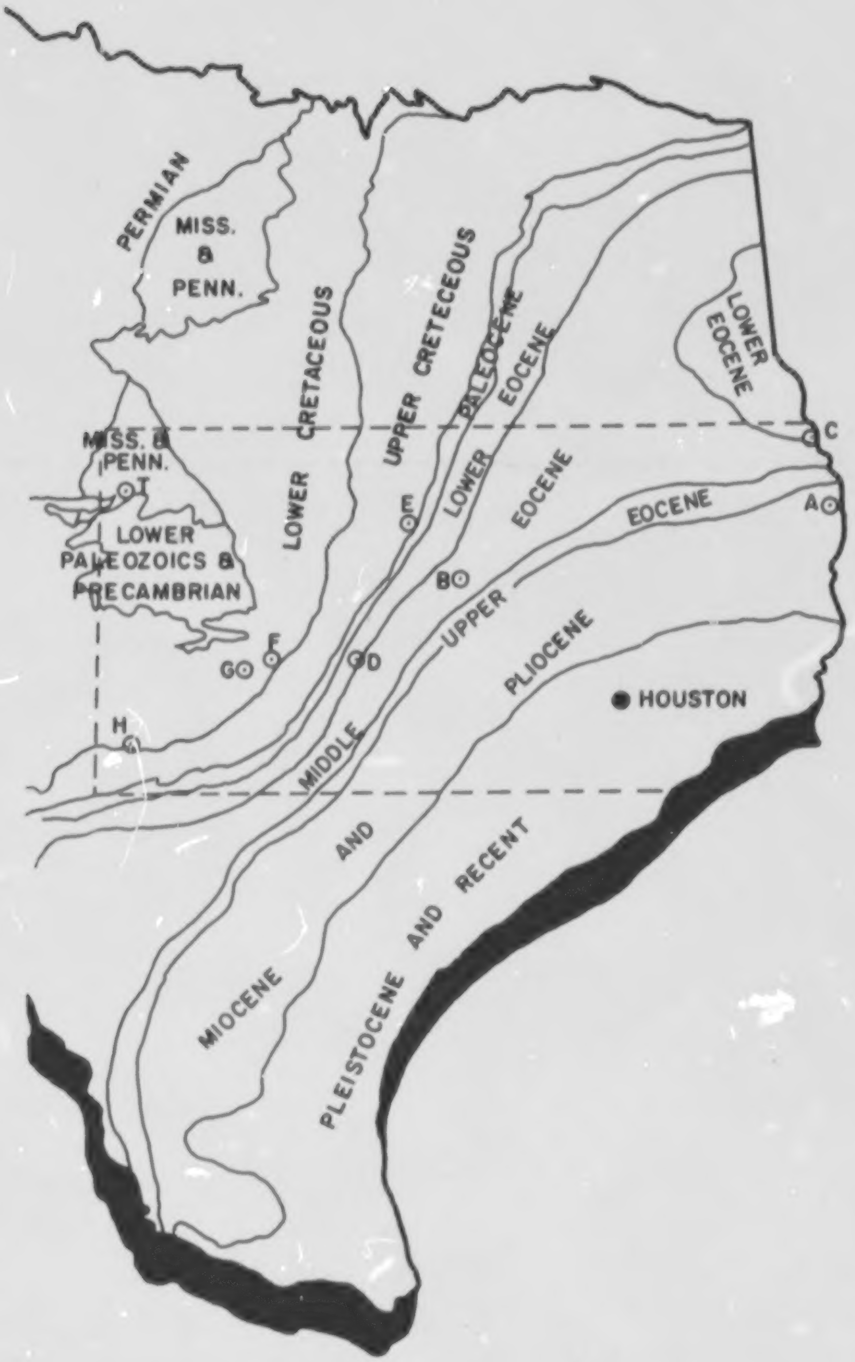
LEGEND

▨ LAND

▨ TRANSITION ZONE-COASTAL BAYS, LAGOONS, MARSHES, DELTAS, BEACHES, ETC.

▤ SEA

GEOLOGICAL MAP OF EASTERN TEXAS


PERMIAN
MISS. & PENN.
LOWER CRETACEOUS
UPPER CRETECEOUS
PALEOCENE
EOCENE
LOWER EOCENE
LOWER EOCENE
MISS. & PENN.
LOWER PALEOZOICS & PRECAMBRIAN
LOWER EOCENE
EOCENE
UPPER
PLIOCENE
MIDDLE
AND
MIOCENE
PLEISTOCENE AND RECENT
HOUSTON
A
B
C
D
E
F
G
H
I

WHERE WAS THE TEXAS COAST IN THE PAST?

Geological history is known only by understanding the biological, physical, and chemical forces which exist today. In other words, we understand the geological past based on what is happening today. We know that certain types of animals live in the seas. When we find fossils of similar animals in rocks inland, we know that the rocks had a marine origin.

For an example, oysters live mainly in brackish water. So if we find a large number of oysters in rocks, we interpret the ancient environment as brackish. If fossils of land animals are found in rocks then the environment was land. However if fossil land animals are found with brackish snail and clam shells then the dead land animals were carried by streams from the areas where the animals lived and died. Based on this knowledge and fossils which have been found maps have been constructed of the Geologic history of Texas.

Look at the maps of Texas from the Lower Cretaceous to the present. Use these maps to fill in the following chart.

Geologic Period	Age in Millions	Location of Transition Zone	Area Under the Sea
Recent - Today	-		
Pleistocene	1		
Miocene	15-25		
Middle Eocene	45-50		
Lower Eocene	50-60		
Upper Cretaceous	65-90		
Lower Cretaceous	90-135		

Questions:

1. Why do we find sea urchin, oyster, clam and other shells in Lower Cretaceous deposits near Austin?

2. What present day Texas cities were on the coast of the Gulf of Mexico, 80 million years ago during the upper Cretaceous?

3. What kind of fossils would you expect to find in the Lower Eocene (55 million years ago) sediments found in the Bastrop and Bryan area?

4. What kind of fossils would you expect to find in the Miocene deposits between Beaumont and Houston? Why?

5. How does the Texas coast during the Pleistocene differ from the Texas coast today? Explain the differences.

TEXAS GULF COAST--PLEISTOCENE TO RECENT

During the Pleistocene glacial stages large glaciers (huge ice sheets) covered the northern United States as far south as New Jersey, Ohio, Illinois and Kansas. During these times the water from the oceans was in the glaciers as ice instead of in the sea. Therefore the sea level was about 450 feet lower than it is today. Most of the continental shelf was above sea level. The shoreline was 50 to 140 miles further out in the Gulf than it is today. Between the glacier periods, the glaciers melted back and the sea level rose to where it is today. The Texas climate between glacial periods was more or less like today's.

During the glacial the rivers flowing across the coastal plain eroded valleys more than a 100 feet deep. During the last of the glacial stages the sediments almost filled in the valleys. The rising sea level filled in the lower part of the deeply eroded valleys. This formed the estuary type of bay which extends several miles inland. So the estuary type of bays is a valley cut long ago by a river and it is now filled with water. Also as the sea level rose, the river current slowed down. This caused the rivers to drop their sediments which led to the filling of their valleys to the present level. The large rivers, the Rio Grande, Brazos, and Colorado, have completely filled in their estuaries and have built deltas into the Gulf of Mexico.

The sea level reached its present position (Recent sea level stage) about 3,000 to 5,000 years ago and has remained the same since. The bay shoreline along the continent is about the same as it was when it reached the Recent stage. Some shores have been eroded back by waves and others have been added to by river deltas. The shoreline on the Gulf side and the barrier islands have been formed since the Recent sea level stage.

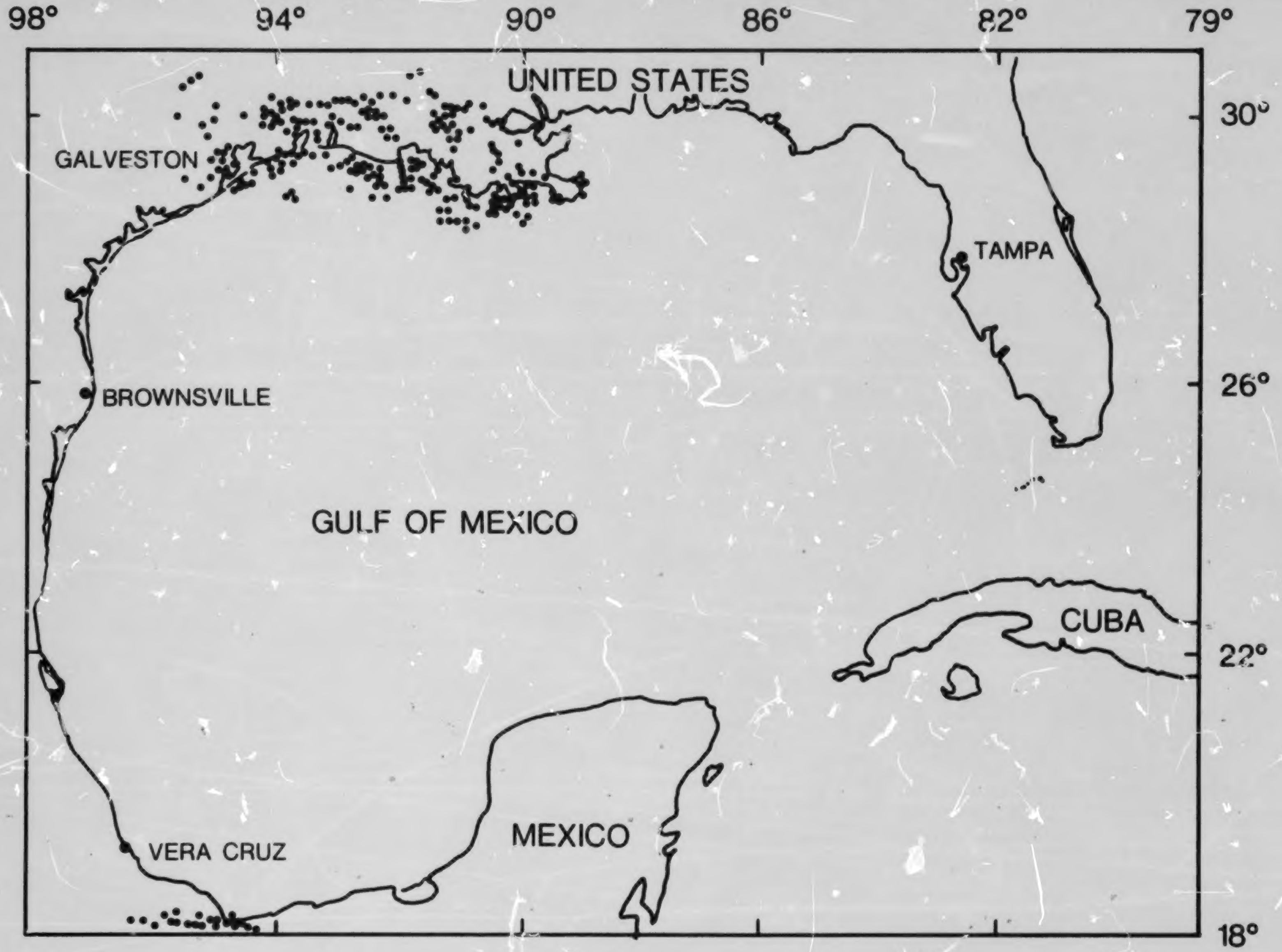
A GEOLOGICAL DECTECTIVE STORY

Our Gulf of Mexico coast is a great laboratory where geologic processes are going on today very much in the same way in which they have been going on for the last million years. Rains erode the land and wash the mud and sand into the rivers.

These rivers carry it into the Gulf. Here the sediment settles out, with each new layer of mud and sand pressing on those beneath. This pressure forced the tiny grains closer together until they formed solid rock. Geologists study these rocks, laid down long ago on the shores of the Gulf of Mexico. They have found that in places oil and gas collect in the tiny spaces between the sand grains. Knowledge of how these form will help geologists locate more sources of oil.

Another exciting discovery is the numerous oval-topped hills that stand above the deep ocean floor along the continental margins in the Gulf of Mexico and in the Mediterranean. Drilling has shown that many of these are domes of salt that have been pushed up through the sediments covering the ocean floor. Salt domes are of enormous value in the search for oil. Salt domes have oil and gas trapped on their sides. Many of the gas and oil fields of the Gulf coast are associated with salt domes.

The salt domes are thousands of feet thick and cover a large area. This means that huge salt lakes or seas must have existed in a climate that was hot and dry enough to evaporate the water and concentrate its salt content. This salt became deposited on the bottom in thick layers. How could this have happened in what was the ancestor of the oceans? We are definitely in the middle of a great detective story. Our new methods in oceanography will bring in new information and maybe solve the mystery of the salt of the salt domes and more.


98°
94°
90°
86°
82°
79°
30°
26°
22°
18°
UNITED STATES
GALVESTON
BROWNSVILLE
TAMPA
GULF OF MEXICO
CUBA
MEXICO
VERA CRUZ

SALT DOMES OF THE GULF COAST

GEOLOGY OF THE GULF OF MEXICO

There are several different explanations for the formation of the Gulf of Mexico. It is believed that when the Atlantic Ocean closed in the Late Paleozoic, it was reduced to small basins -- the Gulf of Mexico and another in the eastern Caribbean. It is possible that neither of these basins existed before the closing of the Atlantic. They may have been formed by the rifting of the crust during the deformation and consolidation of the Paleozoic in the area of northern South America and around the Gulf of Mexico. The Gulf region before the Jurrassic period may have been a relatively shallow and partly landlocked sea.

The Atlantic Ocean began to open in the latest Triassic -- earliest Jurassic. The counterclockwise rotation of Florida during the early phase of the rifting may have resulted in the formation of the subsurface trough on the West Florida Shelf. During the early phase the Gulf of Mexico was a site of evaporite (salts) being deposited.

As the Atlantic widened, the Gulf of Mexico begin to subside (sink). The amount of subsidence, much of which occurred during the Cenozoic was as great as 15 to 16 kilometers. The late Cretacious-middle Eocene deformation of the Rocky Mountains, Northern Central American geosyncline had a great impact on the Gulf of Mexico. Erosion of these structures and the depositing of large quantities of Cenozoic sediments along the margins have led to the reducing of the Gulf to its present size.

The Gulf coastal area is part of a geosyncline which extends from Alabama southwestward to northeastern Mexico. It probably contains sediments over 60,000 feet thick. The sediments are made of mainly alternating layers of sand and shale. These were deposited on deposits from the Cretaceous Period which ended about 65 million years ago. The floor of the Gulf coast geosyncline has subsided (sunk) as sediments have been deposited in it. The subsidence or sinking is rougly proportional to the depositing of the sediments. The Gulf is still sinking today as sediments are added to it.

TOPIC THREE--GEOLOGY OF THE GULF
TEXAS GULF COAST--RECENT

Read and Discuss--

Features of the Gulf Coast

Look at--

Types of Coasts of the Gulf of Mexico Drawing

Complete--

Find the Features activity

Read and Discuss--

Changing Coastlines in Historic Times

Look at--

Drawings of Matagorda Peninsula (before and after Hurricane Carla)
Mississippi River Delta
Colorado River Delta

Read and Discuss--

Trouble in Paradise

Identify--

Ways man has affected the natural processes along the beach or coastline with man-made structures and other actions.

Write--

A short scenario of what you think will happen to the beaches and the coast of Texas in the future (only one area of the coast or the coast as a whole).

Share--

Your scenario with your classmates.

FEATURES OF THE GULF COAST

If you look at a map of the coastline of the United States, you can see different configurations of the shorelines. Even along the Gulf coast there are differences. Perhaps you are most familiar with the sandy beaches along the Gulf. These are on the seaward side of long narrow islands. These beaches are known as barrier beaches. The beach is also classified as a fine-sand beach because the sand will become compacted and hold weight. These beaches are compacted so that cars can drive on them, especially near the shore.

From the air and on maps the long islands appear to be the most obvious features of the Texas coast. They are called barrier islands. The best known barrier island is Galveston Island. Padre island is the longest barrier island. The barrier chain along the Gulf is the world's largest. The barrier islands average about 30 miles long and 2 miles wide, and consist principally of fine sand that extends to a depth of 30 feet. The barrier islands are separated from each other by tidal channels (passes) and from the mainland by shallow bays.

Along the Gulf coast of Texas, the waves break a distance from the shore due to the gentle slope of the shelf. The sand is pushed up, forming sandbars. These sandbars in turn grew into long sand islands - the barrier islands. These islands were widened by sand from their seaward side until they were miles across. They were also built up in part by the winds which picked up the sand and formed sand dunes. The barrier islands may be connected to mainland, at least at one end. Port Aransas, Galveston and Miami Beach are examples of coastal towns built on barrier islands.

Did you ever notice that the bays are of two kinds. One is long and narrow and is parallel to the coast behind the barrier islands. These bays separate the barrier islands from the mainland. This type of bay is called a lagoon. These lagoons average about 3 miles wide, 20 miles long, 6 feet deep and usually they have a mud bottom. Much of the Gulf Intracoastal Waterway is a result of dredging the lagoons behind the barrier islands.

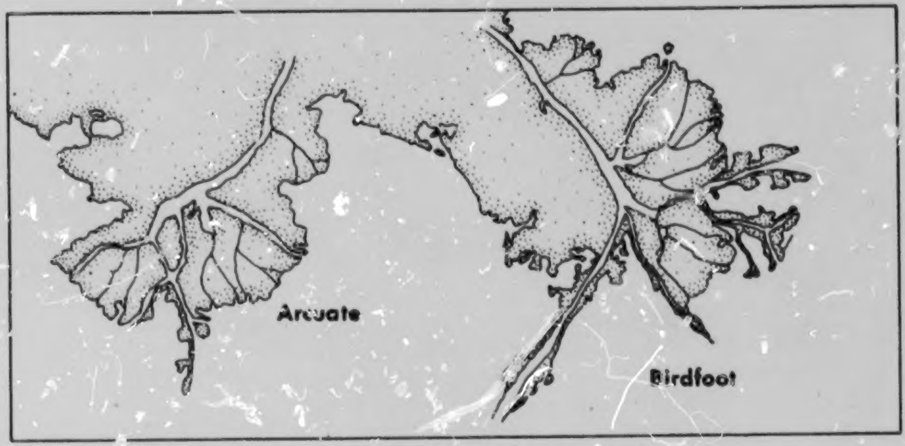
The second kind of bay also is longer in one direction than in the other; however, its long direction is at right angles to the coast. This is the estuary type of bay. An example of it is Galveston Bay and its continuation as Trinity Bay. The estuary bays run about 8 miles wide, 25 miles long and 10 feet deep, and generally have mud bottoms like the lagoons. However the estuaries extend far inland and have rivers entering at their heads which lagoons do not have.

Texas really has two shorelines -- one along the Gulf of Mexico and another along the bays. The Gulf shoreline is on the side of the barrier islands facing the Gulf. It has broad beaches of sand. The bay shoreline is different. It is very irregular, generally flat and marshy without sandy beaches.

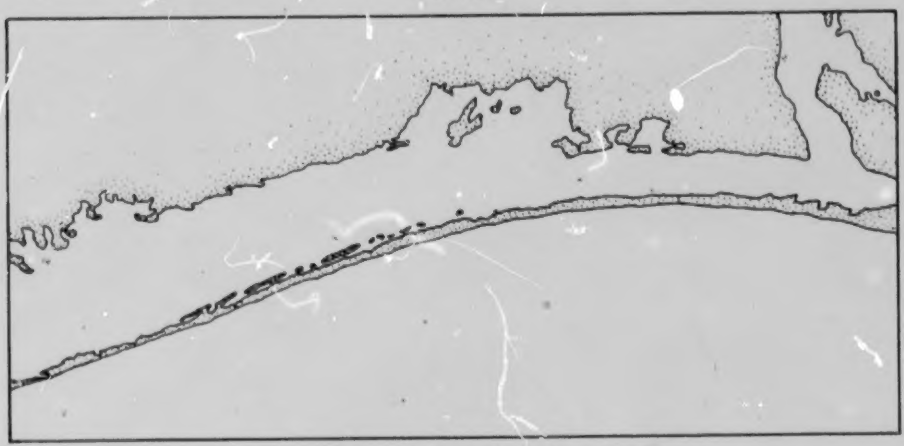
Another feature of the Gulf coast is the deltas which the rivers have built. Most deltas occur near the top of estuary-type bays. However the rivers which carry the most material -- the Mississippi, Brazos, Colorado and Rio Grande -- long ago filled in their estuaries, making them land. They now flow directly into the Gulf of Mexico and are trying to fill it. For example, the Mississippi River, a few million years ago emptied into the Gulf as far up as Cairo, Illinois. Today it has filled in the entire area and is dumping its sediments into the Gulf.

There are also areas along the Gulf coast built by plants and animals. The Florida Keys are a coral-reef coast. They were formed by coral during a period between glaciers when the sea was about 20 feet higher than it is today. Many islands and projections of the mainland along southwestern Florida have been formed by mangroves. They can grow as trees in salt water. A seed pod falls from a mangrove tree overhanging the shoreline and starts a new plant on the bottom. Or the seed might drift out to a shoal and get rooted there. Currents are slowed by the mangrove roots and drop their sediments. In this way the islands and projections along the shoreline develop.

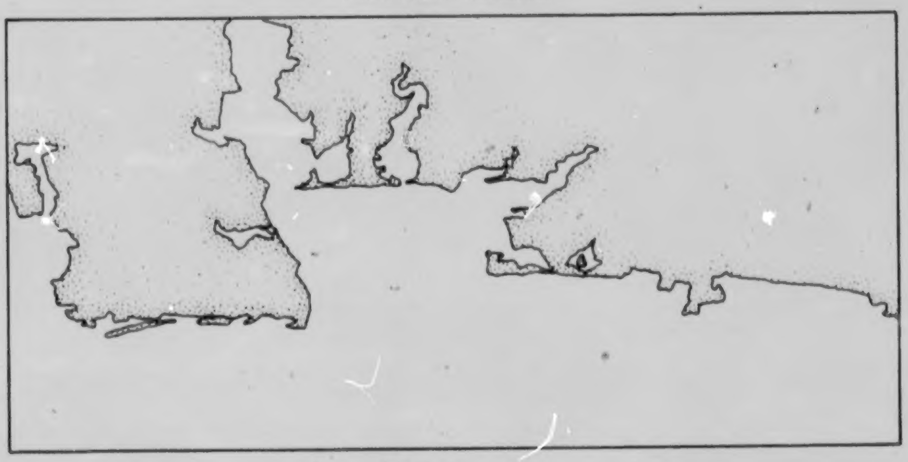
Types of Coasts of the Gulf of Mexico


Arcuate
Birdfoot

Deltas



Barrier Island



Mangrove

FIND THE FEATURES

Obtain a Texas map, highway map or geological highway map and a map showing the Gulf of Mexico shoreline of the United States. Use the maps to complete the following activities.

1. Name the barrier islands along the coast of Texas.

2. A spit is a bar with one end attached to land and the other end in open water across the bay. Locate and name the spits along the Texas coast.

3. How does the shoreline along the Gulf of Mexico differ from the shoreline along the bays?

4. Locate and identify the following:
    barrier islands--
    barrier beaches--
    tidal passes--
    lagoons--
    estuary type of bay--
    peninsulas--
    deltas--

5. Which rivers have deltas built near the top of estuary-type bays?

6. Which rivers have filled their estuaries and are following directly into the Gulf of Mexico?

7. Locate Port Aransas, Galveston, and Miami Beach. Upon what features are they built?

8. Locate the Florida Keys which are a coral-reef coast.

9. Locate the islands and projections along southwestern Florida which are farmed by mangroves.

CHANGING COASTLINES IN HISTORIC TIMES

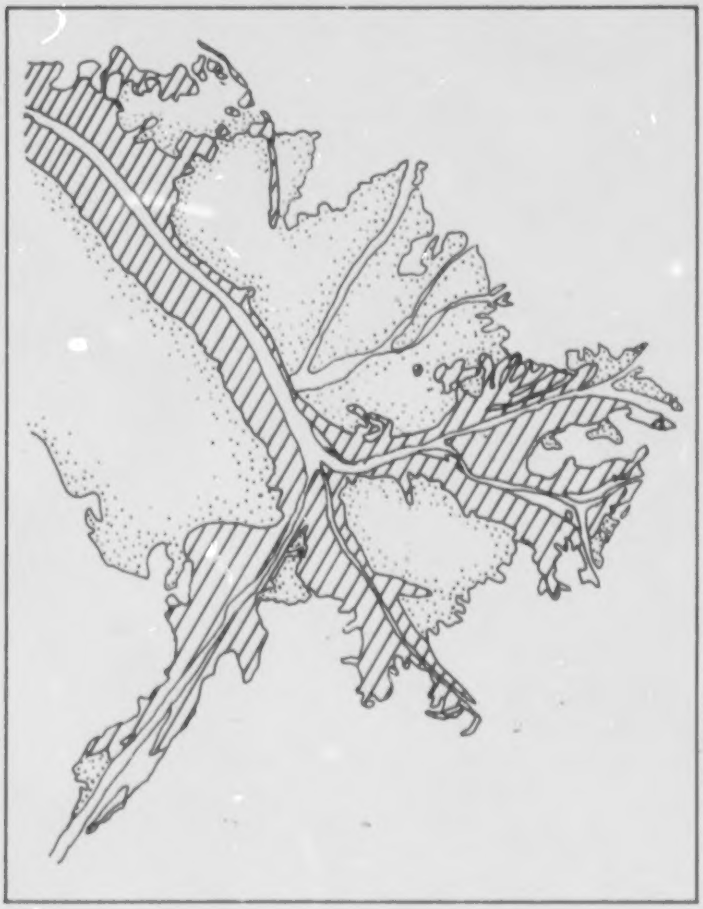
Coastlines are always in the process of changing. Some areas change more than other areas. American surveyors have been keeping good records of the Mississippi River delta. Between 1838 and 1940 in some areas as much as 10 miles of new land have been added. (See sketch) However in recent years there has actually been slightly more loss of land than gain. So Louisiana instead of growing is actually shrinking. This is due to the sinking which occurs in large deltas due to the weight of the sediments. Also the front of a delta grows slower once it has built seaward into relatively deep water.

The Brazos River, the largest in Texas, may have an advancing delta. (See sketch) It had built out almost a mile between 1858 and 1958. The mouth was diverted artificially and the advanced portion of the delta was partially cut away by hurricanes. The present mouth is advancing largely by building arcuate barriers, leaving a lagoon which it later will fill. However hurricanes interfere with this growth so we cannot be sure that this area of the coast is growing.

Another change that can occur is that the sediment from rivers can fill an embayment rapidly. The Colorado River of Texas began to fill in Matagorda Bay in 1929 and by 1950, the river had built a delta five miles across the bay to the barrier island. The U.S. Army Engineers cut a ditch through the islands to allow water to flow out into the open Gulf. There is no sign of a new delta of the Colorado forming into Gulf. A less rapid growth into a bay is seen where the Trinity River is building into Galveston Bay. It has moved forward about a mile since 1855.

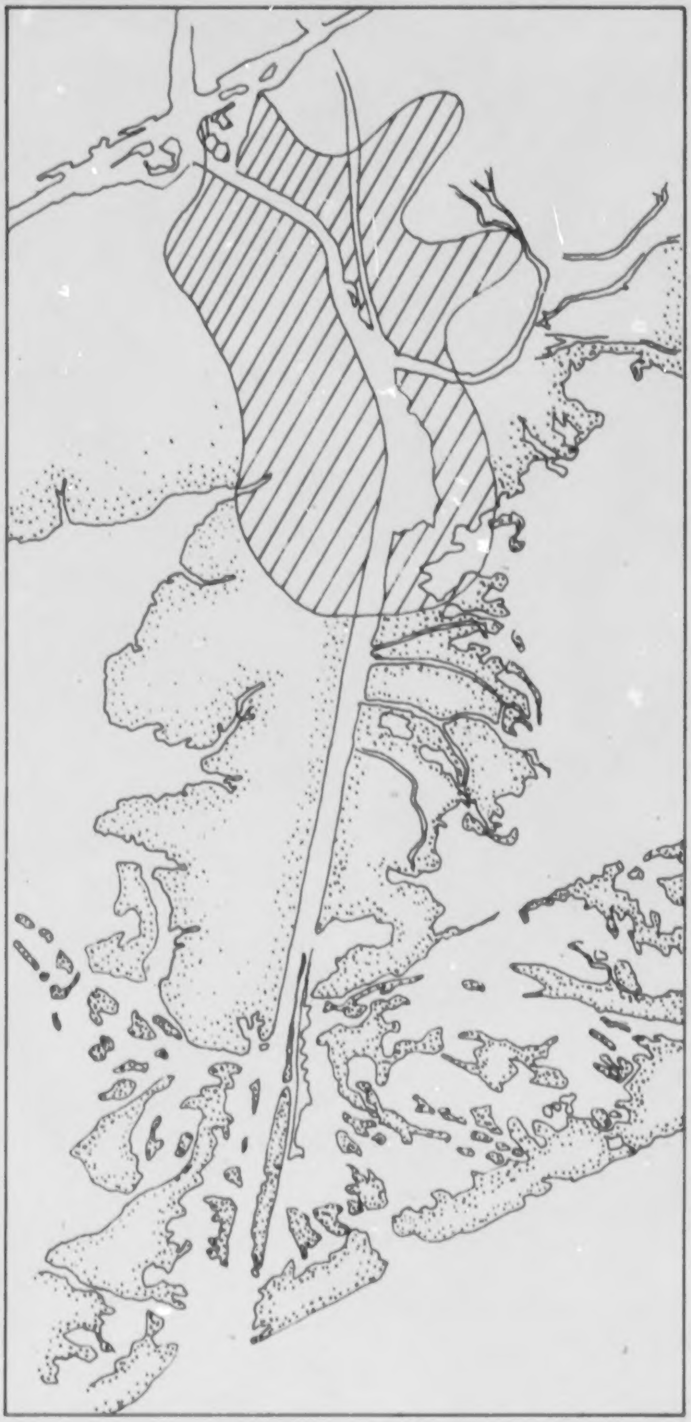
Although most of the Gulf shoreline is growing because of sand being deposited on the seaward side of the barrier islands and by the building of deltas, there are a few exceptions. The best example of this is an area east of Bolivar Peninsula and west of Sabine Pass. Here the erosion of the beach has forced the Highway Department to move parts of Texas Highway 87 further inland a number of times during the last 20 years. Indications are that in some areas the shoreline was eroded more than one thousand feet in the last few thousand years. So here the present day beach is over marshes deposited in the past.

The most obvious short term changes of the coastline are found in barrier islands. Before a large storm or hurricane, the beach may be continuous for many miles along the sea front of the island. Retaking aerial photos after a hurricane shows that the barrier island can change to an amazing degree. After a storm a series of channels usually cut the beach and many inlets extend through to the lagoon on the inside. Also sediment from the beach often forms storm deltas in the lagoon. Some of these may be extensive flats which add to the width of the barrier island and partly fill the lagoon.



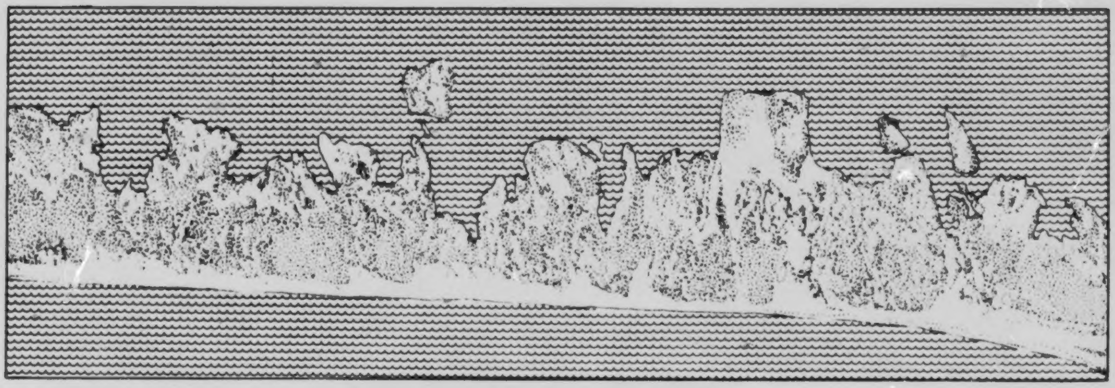
Mississippi River Delta

(Shaded area shows delta in 1838)

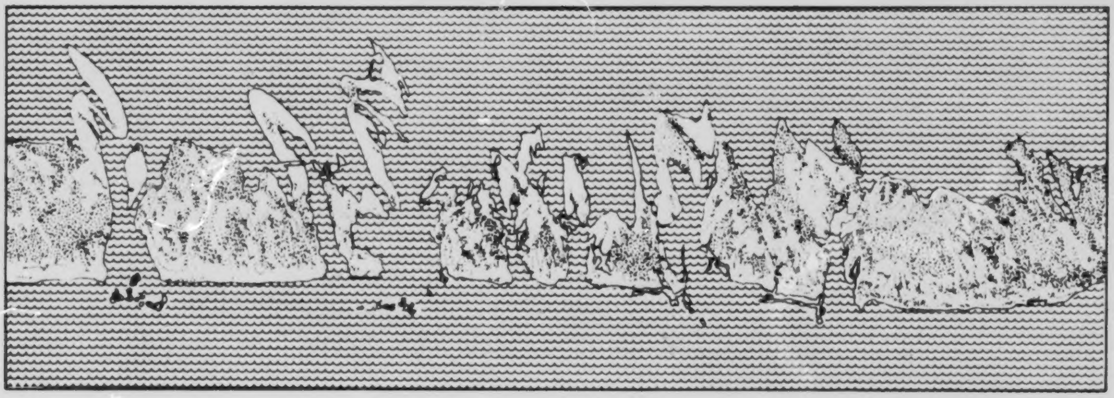


Colorado River Delta

(Shaded area shows delta in 1930)



Matagorda Peninsula 1960



Matagorda Peninsula (After Hurricane Carla 1961)

TROUBLE IN PARADISE

Man came to the United States by sea and migrated inland; today he is returning to the sea. Over half the country's people live in the coastal zone. Ninety percent of the U.S. population growth since 1965 has occurred in the coastal areas. All the reasons may not be clear, although the view of the beach and the water may be as much a motivating factor as any. The sea also brings thoughts of riches, the good life, bodies in the sun, and inspires beachcombers, vacationers, work-weary professionals, land speculators and men who construct buildings on the beach, defying nature to destroy them.

Man may be the chief changer of the coastline. By building dams upstream on a river, the sediments are trapped and not carried to the mouth to be deposited on the beaches. Flood-control dams and basins along the river courses keep even more sand from being carried to the beaches so sand lost to erosion is not being replaced.

Beach erosion is one problem confronting the Texas beaches. One, South Padre Island, appears to be eroding at a rate of 10 to 15 feet a year when 1850-era topographic maps and old aerial photographs are compared with modern infrared photographs.

Like South Padre Island much of the rest of the Texas coastline is eroding, but unlike South Padre much of the remaining coast receives sediments from middle America by way of the Mississippi River. Dams on its tributaries and control of the Mississippi River channel has decreased the sediments deposited on Texas beaches and this, according to some experts, is causing some erosion. At present we do not understand all the forces involved in erosion, much less know how to counteract them.

Ever since the ancient Mediterranean civilizations built ships, man has been building jetties out from the shore to provide areas for ships to anchor and unload goods. These structures have interrupted the sand-carrying currents and have caused erosion on the beach or shoreline along the down-current side. Sand and sediment builds up on the up-current side because it is trapped by the structure, and eventually the sand buildup spills over and fills the harbor. Man will probably always affect the coastline as long as he lives on it. The question is, what will be the detrimental effects of man on the coast?

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

ACTIVITY ONE--The Smell and Taste of the Sea
ACTIVITY TWO--The Noisy Deep (Sounds of the Gulf)
ACTIVITY THREE--The Light and Dark of It
ACTIVITY FOUR--The Hot and Cold of It
ACTIVITY FIVE--A Little Salt and the Force
ACTIVITY SIX--Density and the Sea
ACTIVITY SEVEN--It Moves!

Materials for Classroom Use:

Water, salt, milk carton, 2 magnets of different sizes, iron filings, plastic straw, small balls (2 sizes), glass container, food coloring, ice, heat source, medicine dropper
Tape recorder
Cassette tape "The Noisy Deep"
Monsters of the Deep/reading
Sea Monsters/drawings
Voices of the Noisy Deep/reading
Sound in the Sea/reading
The Light and Dark of It/activities
Light Pentration/drawing
Light in the Sea/reading
Temperatures of the Gulf/ chart
The Hot and Cold of It/reading
Sea Ice Formation
The Frozen Seas
A Little Salt/reading
Salinity of the Gulf of Mexico/chart
What is Salinity?
The Force--Pressure/reading and questions
Sea Water and Pressure/activity
Importance of Salinity and Water Density/experiment
Effects of Temperature on Water Density/experiment
Water System Like the Ocean/demonstration
Sea Water and Density/reading
Major Ocean Currents/drawing
Currents/readings and questions
Surface Currents in the Gulf of Mexico/reading
Surface currents in the Gulf of Mexico/drawing
Tides/ diagram
How Tides are Formed/demonstration
How the Sun and Moon Affect Tides/demonstration
In and Out--The Tides/reading and questions
Waves/reading
Cause of Waves/experiment
Catastrophic Waves/reading
Say it with a Dance/activity

Major Objectives for the Topic:

After completing the activities the student will be able to:

1.1 define salinity, pressure, density, tides, currents, and waves;
1.5 discuss the factors which affect the smell and taste of water;
1.5 describe the sounds that are heard in the water;
1.5 state the factors that affect light penetration in water;
1.5 discuss the importance of light penetration;
1.5 state the factors that affect the temperature of water;
1.5 describe the characteristics of sea water and the behavior of ice in sea water;
1.5 analyze the factors that affect the salinity;
1.5 describe the effect of pressure in the sea;
1.5 state the factors that affect the density of sea water;
1.5 construct a model to illustrate currents;
1.5 make a statement relating density of water to the movement of water masses;
1.5 explain the formation of waves;
1.5 illustrate the relationship between tides and the gravitational forces of the earth, the moon and the sun;
1.5 explain how the flow of energy from the sun generates currents;
1.5 construct an experiment to illustrate the causes of waves;
1.5 describe the effects of currents on climate;
2.7 cite ways in which currents affect and have affected man;
2.7 cite examples to illustrate why the knowledge of tides and currents is important;
4.1 analyze the feelings and perceptions that sounds of the Gulf produce;
4.1 evaluate the feelings produced by waves, tides and currents.

Teaching Suggestions:

The purpose of this lesson is to present information to the student on the physical characteristics of the marine environment and factors affecting these characteristics. Select the activities which will best meet your students' needs and the objectives of your course.

1. Have the students complete the reading and activities and respond to the questions and/or activities.

2. During the days on which these activities are used, have the students meet in small groups to discuss the questions and/or cooperatively work on activities.

3. After each activity have a class discussion on the questions and/or activities. Encourage students to generate related questions and then strive to answer them cooperatively.

4. The smell and taste of the sea activities are designed to be simple yet illustrate to the students the concept that it is the substances in the water that determine the smell and taste of the water.

5. First have the students imagine what sounds they would hear on the beach and discuss these. Then, to set the stage for listening to the sounds on the audio cassette tell the students to imagine that they are in a submersible in the Gulf. Since it is dark in the depths you may want to turn off the classroom lights and listen to the sounds that the submersible's hydrophones (microphones in the water) pick up. Be sure you stress sounds--do not say animal sounds. Tell them to listen and try to determine what is making the sound. After listening to all the sounds, turn off the audio tape and have the students discuss the sounds and answer the questions. You may then play the second portion of the tape which has the sounds identified or you may want to have the students read "Monsters of the Deep" and look at the drawings before you listen to the portion of the tape with the sounds identified.

(The audio cassette "The Noisy Deep" has eleven sounds unidentified with a short pause between each. There is a pause after the unidentified sounds and the sounds are then repeated with narration identifying each sound.)

As they appear on the tape, the sounds are:

1. snapping shrimp
2. toadfish
3. trigger parrotfish
4. sea catfish
5. single catfish
6. white grunt
7. drumfish
8. cowfish
9. manatee
10. one porpoise
11. school of porpoises
12. whale

The audio tape was taken from the album Sounds of Sea Animals, Vol. 2, Folkways Science Series Fx 6135, Folkways Records & Service Corp. 43 W. 61st, N.Y. 10023.
(additional references at the end of this section)

6. After listening to the audio tape and reading Voices of the Noisy Deep, have the students identify ways in which they can produce sounds without using their vocal cords. Some are whistling, snapping finters, popping finger joints, clapping fingers together, clapping hands, clapping arms, rubbing hands and arms together, clapping feet together, stomping etc. You may even have the students work out a way of communicating by using these sounds.

7. The Light and Dark activities are designed to point out the effect of materials in the water on light penetration. You might point out that sediments from the Mississippi and other rivers are carried by currents along the Texas coast so the water is not clear and blue, yet these same sediments provide the nutrients for our Gulf fisheries.

8. The experiments on the freezing of salt water and the building of a hydrometer are simple.

9. The experiments in Density and the Sea are excellent demonstrations of salinity, temperature and the movement of water masses in the ocean.

10. After looking at the diagram of the main ocean currents have the students color the warm currents red and the cold currents blue so they will be easier to identify. You may have the students use a World Almanac and look up the temperatures of several major cities that are in the same latitude but have either a cold or warm current flowing near them. This will help them recognize that cities in the same latitude may have different climates due to the influence of the warm and cold currents.

11. As part of the tide activities, you may want to have your students read a tide table and plot tidal highs and lows for a week. Different students or groups may plot the tidal curve of different coastal locations and then compare and discuss the results.

12. The Say it with a Dance activity is to help the students understand the rhythmical movement of the sea, its strength and how it inspires. By actually moving to illustrate the various movements of the sea, it will also help the students understand each.

13. Additional References

Our Restless Tides. NOAA, National Ocean Survey, Rockville, Maryland, 20852 (free pamphlet).

Tide Tables 1976 East Coast of North and South America. U.S. Dept. of Commerce, National Ocean Survey, Rockville, Maryland.

Why the Sea Is Salty? U.S. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. (free pamphlet).

The Ocean World of Jacques Cousteau, Vol. IV, Window in the Sea--Light and Vision Underwater, Vol. VII, Invisible Messages--Sound-scent, Vol. XIII, A Sea of Legends--Sea Monsters.

Texas Parks & Wildlife Magazine, Vol. 37, No. 7 (July 1979), "Texas Sea Monsters," p. 16-19.

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

THE SMELL AND TASTE OF THE SEA

Smell--

Two water samples.

Answer--

The questions on water and its smell.

Taste--

Two water samples.

Answer--

Questions on the taste of water.

Evaporate--

Two water samples.

Observe--

Experiment.

Answer--

Questions.

SMELL

This is Capt. Al G. Seaborne again. I would like you to help me check out some of the ocean's physical characteristics in the Gulf. Let's begin by using our sense of smell. You have two samples of water. Sample A is distilled water. Sample B is salt water.

Smell each sample of water.

Answer

1. What does each sample smell like?
2. What do you think gives water its odor?
3. Does the salt water sample smell like the water in the oceans? Explain.
4. Why does the water from ocean smell different than your sample of salt water?
5. Would water from all the oceans smell the same? Explain your answer.
6. What would make water smell bad?
7. What could you do to change the smell of water (either good or bad)?
8. What effect do you think pollutants would have on the smell?

TASTE

Taste -

1. The distilled water sample.
2. The sea water sample.

Answer -

1. How would you describe the taste of the distilled water?

2. How would you describe the taste of the sea water?

3. What makes the sea water taste the way it does?

4. Does the salt water sample taste like water from the ocean? Explain if there is a difference.

5. Would salt water from all the oceans taste the same? Explain your answer.

6. Can we change sea water to fresh water?

Evaporate -

1. A sample of distilled water.
2. A sample of sea water.

Answer -

1. Do you get the same results from evaporation of each sample? Explain.

Taste -

1. The material left after the evaporation of each sample.
2. What could you say about what affects the taste of sea water?

3. Would other materials added to water affect its taste?

4. What effect do you think pollutants would have on the taste?

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

THE NOISY DEEP
(SOUNDS OF THE GULF)

Read and answer--
The Sounds of the Gulf.

Listen--
To cassette tape of The Noisy Deep.

Record--
Your impressions.

Answer--
The questions about the sounds you heard.

Read--
Monsters of the Deep.

Look at--
Drawings of sea monsters.

Use--
The library to look up additional stories about sea monsters.

Read--
Voices of the Noisy Deep.

Determine--
Ways in which you can make sounds without using your vocal cords. Use only hands, feet

Discuss--
The sounds you produced and their communication possibilities and the possibility of animal sounds being a means of communication.

Read--
Sounds of the Sea.

THE SOUNDS OF THE GULF

This is Capt. Seaborne. We are going to investigate the sounds of the Gulf. First close your eyes. Imagine that you and I are standing on the beach with the water to our right and sand dunes to our left. Listen in your imagination.

1. Describe what you would hear and feel.

2. List as many of the different sounds that you think you would hear.

3. What are some sounds that you did not hear on the tape that you might hear?

4. Will the sounds always be the same or will they differ? Explain.

Now we will continue our investigation. You and I have now entered the mini-sub and are starting our descent into the depths of the sea again. We stop our descent and our engines are stopped. Our outside microphones are turned up. Let's listen to the sounds around us for a few minutes. (Sounds on audio tape).

1. Record your feelings.

2. List as many of the different sounds you heard that you can remember and identify what you think is making the sound.

3. If you were a sailor lying in your bunk on a sailing ship in the 1700's, how would you feel if you heard these sounds and what would you think they were?

4. Could these sounds be the sounds of ghosts and spirits about which sailors of the past talked? Why or why not?

MONSTERS OF THE DEEP

Over the centuries there have been thousands of reports of the sightings of gigantic and fantastic sea creatures. From the very first time that man went to sea, sailors have brought back tales of all sorts of strange and fantastic creatures.

The earliest known story is dated about 400 B.C. and even then it was considered an old story. However, in writings of 800 B.C. two horrible marine beasts are described. Herodotus, a Greek historian in the fifth century B.C., writes of a one-eyed sea monster that was part fish and part lion. He also wrote of sea monsters with human heads and humans with sea monster heads or sea serpents with human hands and feet. Of all the legendary creatures of the sea, the sea serpent was one of the most terrifying as well as one of the most popular. According to legend, these creatures would attack ships and eat the crews.

As the sea travel increased and ships sailed out of the sight of land, reports of sea monsters increased. Shortly after 1000 A.D. King Sverre of Norway first used the word kraken to describe a sea monster. The kraken in reality is a giant squid, octopus or cuttlefish, but the imagination of man made them gigantic. In fact drawings show them so large that they can snatch a sailor from high on the riggings of a ship.

In the middle ages, the early scientists felt that every land animal had a counterpart in the sea. So there were sea horses, sea dogs, sea cows, sea lions and sea elephants. They were partly right. They also felt that counterparts of human beings might also be found in the sea, and believed there was a sea bishop, sea monk, etc.

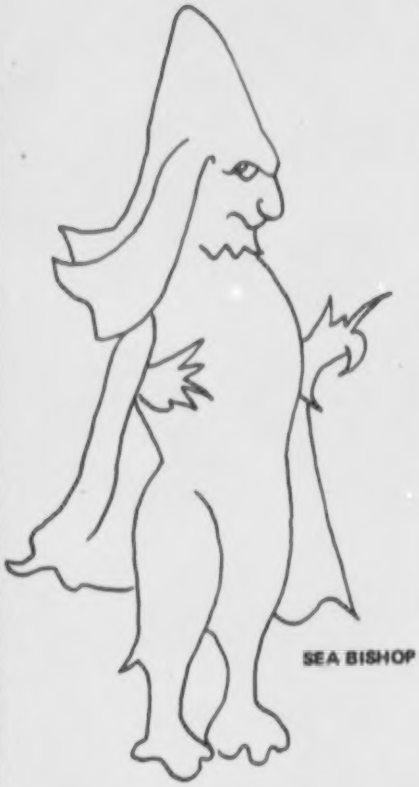
All countries have stories and reported sightings of sea monsters. Many sea monster stories have circulated even in the twentieth century. No monster has had more newspaper coverage than our present day Loc Ness Monster.

There are various explanations for the sea serpent stories. A sea captain mistakes floating seaweed half a mile away for a sea monster; this results in the story of a sea creature seen swiftly advancing against wind and sea. Occasionally fallen trees or masses of floating underbrush can suggest strange shapes. Several sightings in the 1800's were found to be only trees and brush on close inspection.

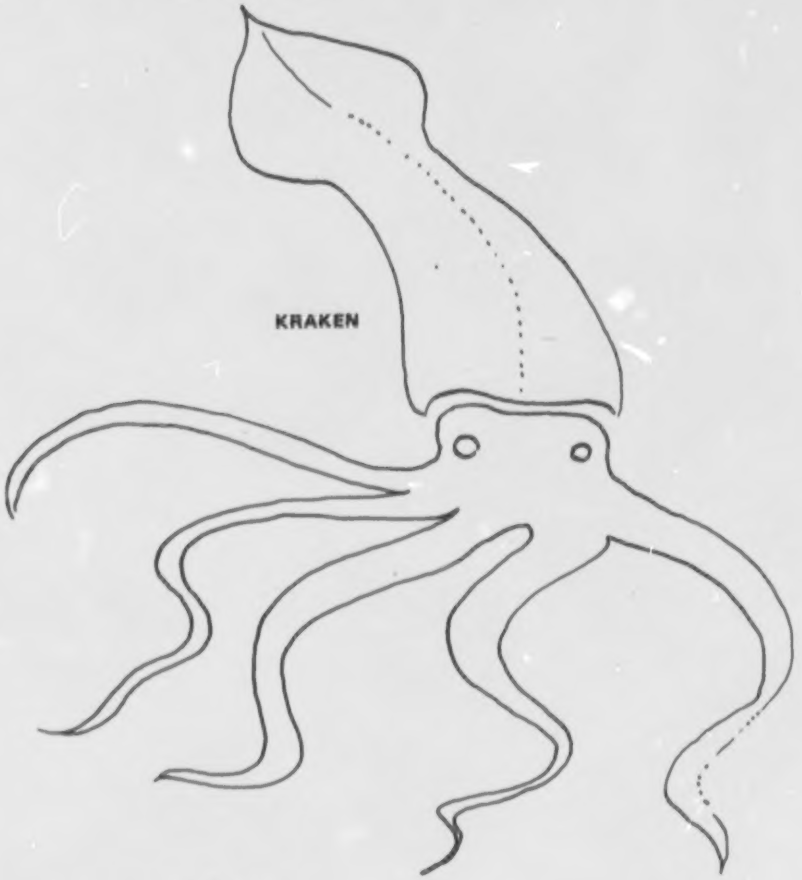
There are many stories of wierd sea monsters that have suddenly appeared to attack snips and take sailors away. Giant squid and octopus do exist, including some over 60 feet in length. These could be the reported kraken. Without a doubt, a snake swimming in the ocean could be considered a sea monster. A variety of African python can swallow a cow. These snakes have been known to swim from island to island. If a tired snake (over 20 feet long) swimming in the ocean saw a ship, he would probably climb aboard and eat a few of the crew. The snake would only board the ship to rest, but sailors would be terrified. It is certain this event would be retold often with the snake getting larger with each telling.

Numerous people claimed that what they saw or what other sightings describe are remnants of the prehistoric era. This is true of the coelacenth, fish declared extinct but caught alive in 1938 and several times since. The way we fish the ocean with hooks and nets (usually around 60 feet) we are unlikely to catch a monster that lives 20,000 to 30,000 feet down. All the caverns, hills, canyons and mountains in the ocean depths have not been explored. There might be a sea monster in the depths, or perhaps someone just invented the sea serpent story.

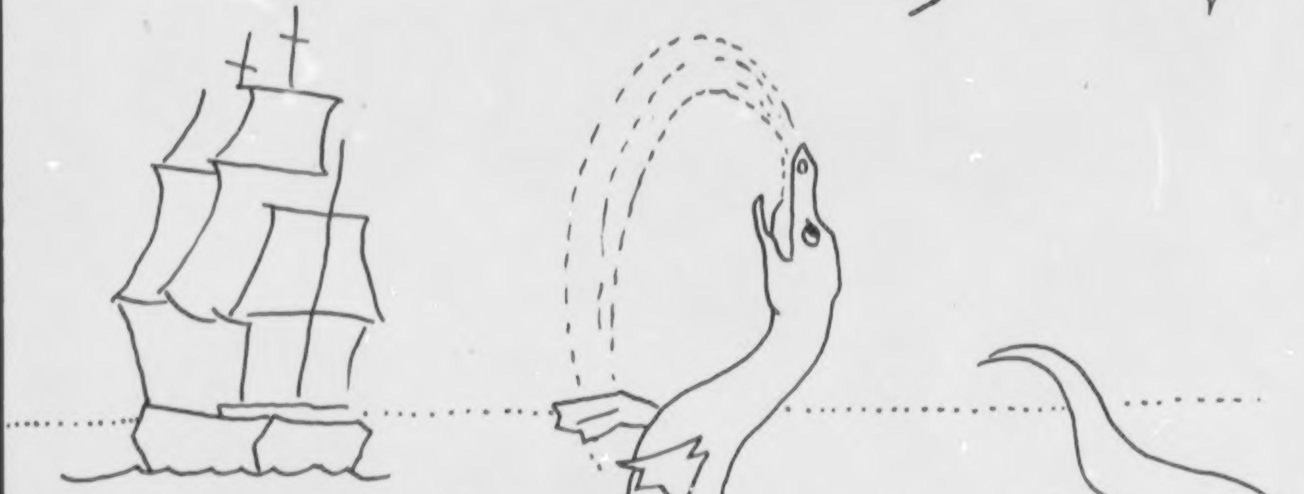
SEA MONSTERS



SEA BISHOP

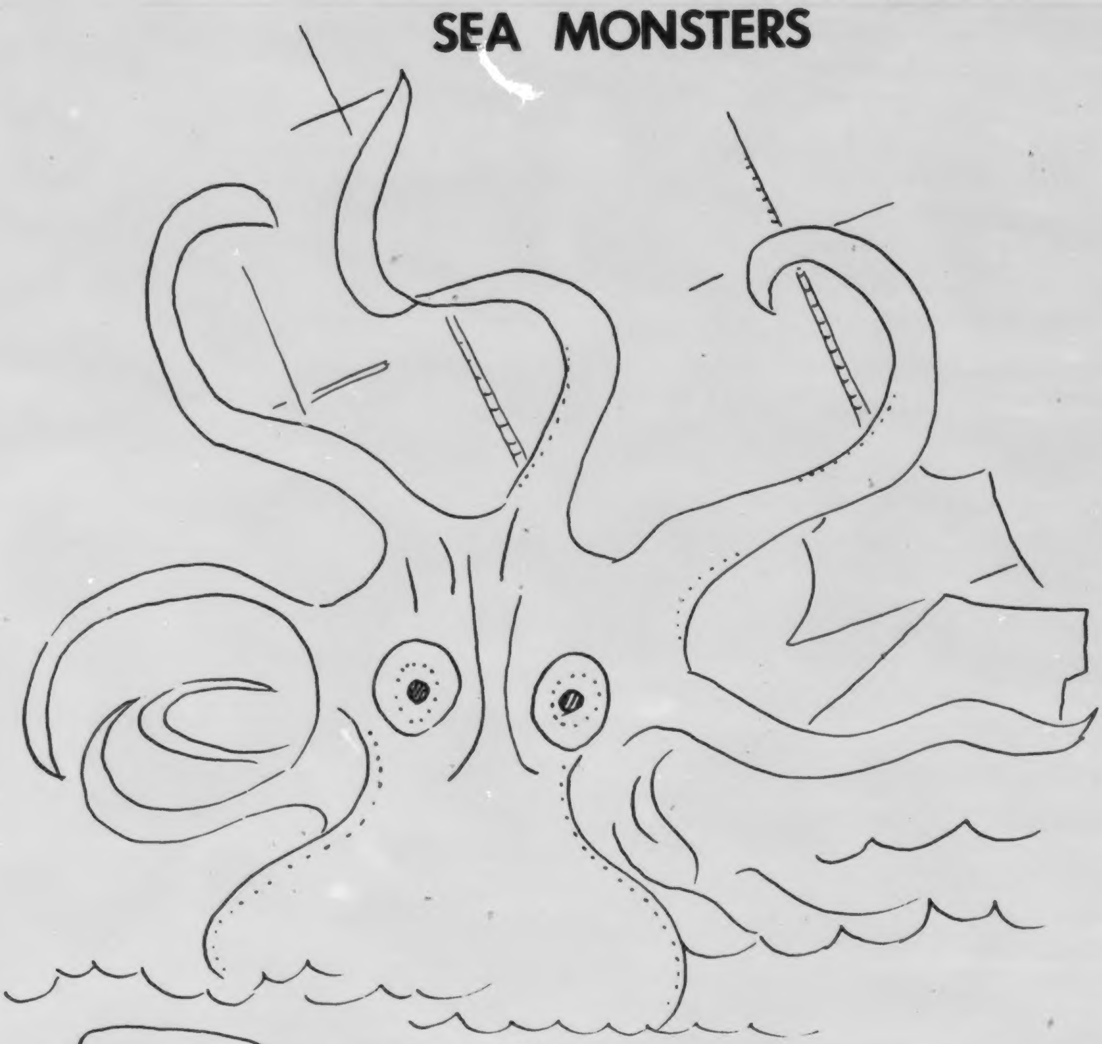


KRAKEN

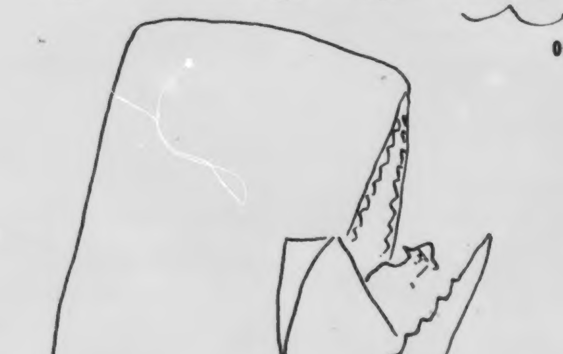


SEA SERPENT

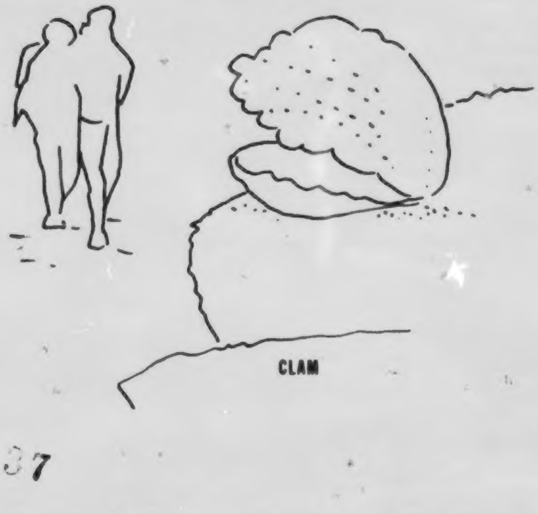
SEA MONSTERS



OCTOPUS



MOBY DICK



CLAM

VOICES OF THE NOISY DEEP

In the sea a variety of sounds are broadcast by a multitude of organisms. The most frequent and prolific sound producers come from three groups of animals - fish, crustaceans and mammals. Scientists are studying how, when and why organisms produce the various sounds. So far, only a small part of the whole story is known.

The sounds of each organism are a voice print, or fingerprint of the sound. Once a spectrogram is made of the sounds of an organism, it can be used to determine if an unidentified sound was made by the same organism. For an example a sonar-listening device picked up a sound which sounded like a submarine distress signal. Further investigations failed to locate a submarine in the area. Spectogram analysis of the sound tapes indicated the sounds were not from a submarine but made by a drumfish.

No fish, crustacean or other invertebrate animals have vocal cords to help produce sound. They use a number of other methods to do so. Some produce sounds by rubbing, or grinding together, hard parts of their body. This is called stridulation.

Fish of the grunt family produce gruntlike sounds by grinding their upper and lower pharyngeal teeth in their throat. Their swim bladders resonate and amplify these sounds. Croakers produce croaks or bumps by vibrating the strong muscles on the sides of their swim bladders much the way a guitar string vibrates when plucked. Drums are the best known of the sound-producing fish and they also produce sounds by vigrating the muscles attached to the swim bladders. Drums give off noises of varying pitch - from deep drum-like thumps to higher pitched sounds. The snappers. sea robins, damselfish, angelfish and squirrelfish also use the swim bladder and associated muscles to produce sound. The resulting sounds have been described as weak knocks, thumps, bumps, booms, staccatos, grunts and growls. The toadfish produces two sounds - grunts and boat whistles. Filefish produce sounds described as the tearing of canvas, grinding grating, rasping and scratchy clicks by grinding their teeth. Puffers, Porcupine fish and Burr fish produce scraping and thumping sounds mainly when they are inflated by grinding their mouth plates together.

Mussels and clams secrete threads to anchor themselves to rocks and to each other. To move, they must break these lines, producing the primary background crackling sound heard outside of tropical waters. Pistol shrimp clap the two parts of their large claw together to make popping sounds. Spring lobsters have noise-making devices located at the base of their antennas.

The marine mammals produce several types of sounds. They may click, grunt, whistle, tick, sigh, wheeze, cluck or rumble. Dolphins and humpback whales may emit sounds and repeat them a varying number of times. They even produce a series of phrases in different sequences.

Sea creatures often makes sounds in response to hunger, fear, light, anger or aggression. They may have many reasons for making sound. Noises may be used for species or sex identification, navigation, for schooling, as a threat or to express danger.

Research has found hundreds of different types of sounds in the sea and will find more. What is the behavior associated with each sound? Are these animals actually "talking?" Can this communication begin to be classified as language? Will we talk to the marine animals one day?

SOUND IN THE SEA

Invisible messages can tell us much about the ocean and its topography. Some of these messages are the echos of sound we have beamed at the ocean floor. We use echo sounders and sonar (sound navigation and ranging) which use sound waves to study the ocean. Sonar is an underwater equivalent of radar.

These instruments have three basic parts: a transducer, hydrophones and a timer. The transducer is aimed vertically in echo sounders and obliquely in sonars. The transducer vibrates when when it receives an electrical impulse and these vibrations make sound waves in water which travel in the direction it is pointed. When the sound waves strike a target, they are bounced (echoed) back to the hydrophones mounted on the ship's bottom. The hydrophones sense the echoes and translate them into a paper recorder or on a screen. The timing device indicates the length of time the sound took to travel which tells us the water depth of the object. The information provided by these echoes gives the location of a submarine, a school of fish, vertical migrations and schooling habits of some marine organisms, and the topography of the ocean floor even when it is partially buried under miles of sediment. It also can be used for emergency signals.

Marine organisms interfere with the operation of sound ranging devices in several ways. Systems that listen to detect characteristic noise of ships, submarines or other activities are especially troubled by noises made by marine organisms. Their sounds have been confused with ships' engines, propellors and other equipment. Whales occasionally give off signals like a submarine since their movement, color and shape is very similar to a submarine. Even the octopus dragging on shells along the bottom has interferred with sound ranging.

Sound travels faster in water that in air. The speed of sound in the sea varies from about 1,450 to 1,550 meters per second. The speed of sound increases with increasing temperature, salinity and pressure. The higher the frequency of the sound waves, the less they penetrate the water. Medium and low-frequency sounds travel well through the ocean.

Although noises do exist underwater and travel clear, fast and far, to a diver they sound very muffled. First, to hear sounds underwater, a diver must hold his breath or the sound of his exhaust bubbles will drown out the other sounds. Marine organisms are much better equipped for hearing underwater. Air bubbles in the canal of man's outer ear and the air space in the middle ear block out many sounds. Man must rely on mechanical sensors to aid in listening to and understanding the sounds in the sea.

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

THE LIGHT AND DARK OF IT

Complete--

The activities and questions in The Light and Dark of It.

Look at--

Drawing of Light Penetration.

Read--

Light in the Sea.

THE LIGHT AND DARK OF IT

Look at -

An object in the room. Now look at the same object through salt water.

Record -

Your observations.

Look at -

The same object through water solution with dirt or sand mixed in it.

Record -

Your observations.

Look at -

The same object through the water solution with the light out.

Record -

Your observations

Answer -

1. Was there a difference in your being able to see the object in each instance? Explain.
2. What made the difference?
3. Can you see underwater as well as you can see on land?
4. What must be present so you can see an object: (Why can you see an object better during the day than at night?)

5. Would you be able to see in 10 feet of water as well as in 5,000 feet of water? Why or why not?

Look at -

The drawing on light penetration and use it to help answer the questions.

Read -

The Light and Dark of It.

Answer -

1. Would you be able to see on the floor of the Gulf (12,000 ft.)? Explain.

2. Why are no plants generally found below 650 feet?

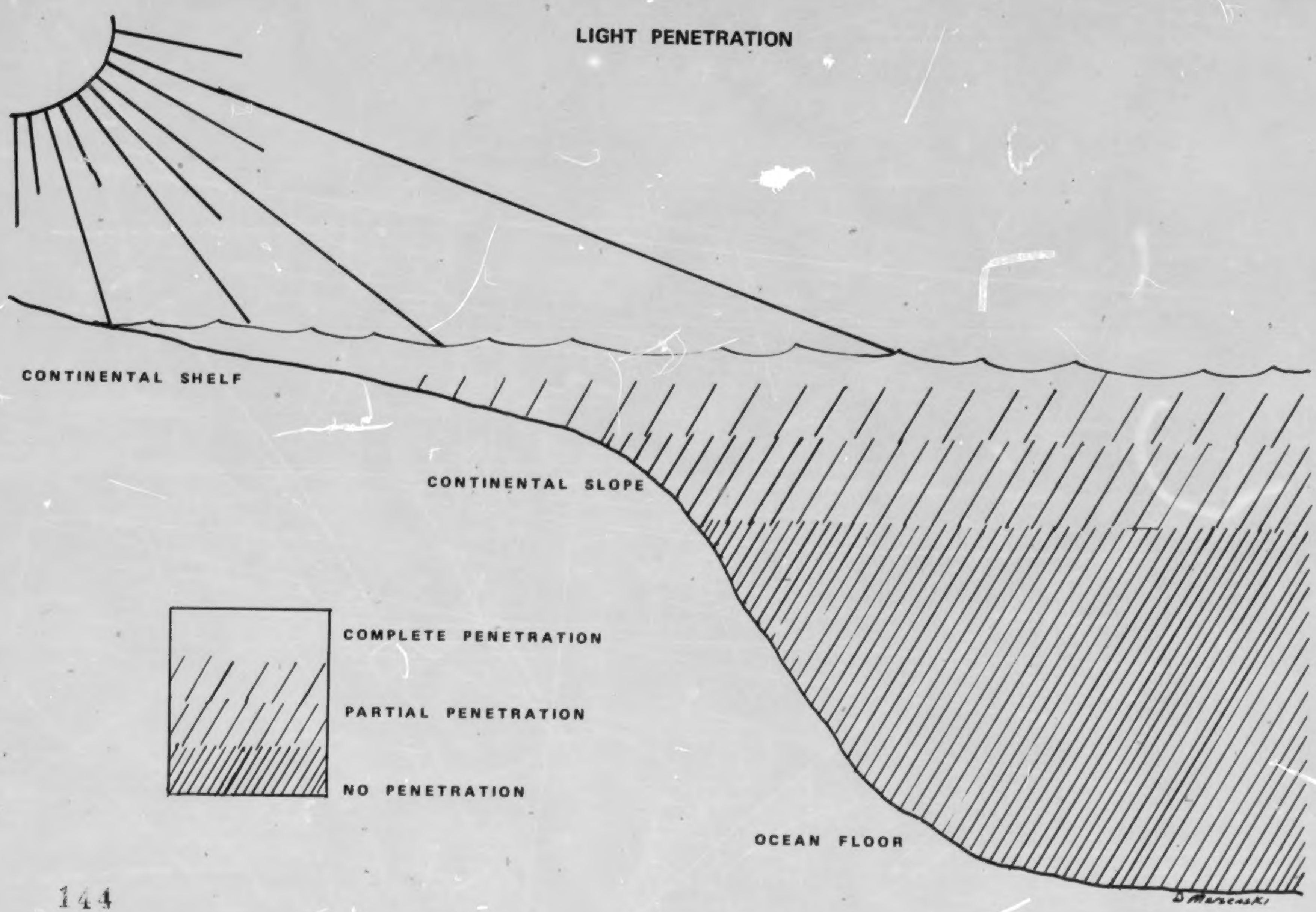
3. Why is light penetration a critical factor in the ocean?

4. Would the light penetrate the same distance in the middle of the Gulf of Mexico as near the mouth of the Colorado, Brazos, or Mississippi Rivers? Explain.

5. What determines the color of the ocean?

6. How can man affect the light penetration?

LIGHT PENETRATION


CONTINENTAL SHELF
CONTINENTAL SLOPE
COMPLETE PENETRATION
PARTIAL PENETRATION
NO PENETRATION
OCEAN FLOOR

LIGHT IN THE SEA

As light reaches the surface of the sea, part of it is reflected and the rest penetrates the water. Reflection is least when the sun is directly overhead (about 2 percent on a calm sea). It increases to almost a 100 percent reflection as the sun approaches the horizon. The amount of light that actually enters the sea varies depending on the angle of the sun, sky conditions, sea surface condition and the clearness of the water.

Water transmits light very poorly. Since all life depends on sunlight directly or indirectly (photosynthesis), the optical properties of seawater are very important. Sunlight, because it is scattered and absorbed rather rapidly, can only penetrate to a limited depth in seawater. One can compare clear tropical waters where visibility is 200 feet to 200 feet of visibility on land in a dense fog.

Water also selectively absorbs some colors, allowing others to penetrate. Objects appear a certain color when they contain the proper pigment to reflect that color light. Red light does not penetrate water easily and does not reach below 30 feet. Where there is no red light, red objects appear as dull gray. In the clearest ocean water, blue light penetrates the deepest (more than 500 meters). At depths of about 600 meters, the intensity of light may be equal to that of starlight reaching the surface of the earth. Descending further, other colors become muted and disappear until the whole undersea would appear in shades of blue-gray. In the depths where no light is present, it is black.

To see color, white light, containing all colors, must be present. Divers using artificial light see the reefs explode with color, showing fish for the first time and the colorful beauty of their world. Without the white light, the reef would only appear in shades of blue-gray.

The color of the ocean is due to the color of the light reflected from the surface and the light that is back-scattered from within the sea. Since blue and green have the greatest chance of penetrating seawater, they also have the greatest chance of being back-scattered, making the sea appear blue or green. Near shore the water tends to look more greenish due to the scattering of light by substances from decomposing plants. Highly turbid water tends to appear brownish because of the reflection of light by brownish suspended sediments. Therefore, the color of the water will be determined by the suspended materials.

Usually not enough light penetrates beyond 1,600 feet (490 meters) to be visible to the human eye. In fairly clear coastal waters, most light is filtered out in the upper 50 meters. In very muddy coastal waters light may not penetrate more than the first meter especially near the mouths of rivers carrying a heavy load of sediments.

Assemblages of organisms with common characteristics are found in the narrow sunlight zone of the oceans. Since plants can obtain energy from the sun only in this lighted zone, it is only here that the food chain, the plant-herbivore-carnivore, can develop.

The Deep Scattering Layer (D.S.L.) or the "false bottom" recorded on echo sounders is actual produced by a mass of deep sea animals migrating up and down depending on the light penetration from day to night. The layers of animals swim toward the surface as night approaches and descend in the morning.

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

THE HOT AND COLD OF IT

Look at--

Chart on temperatures of the Gulf of Mexico.

Read--

Temperature of the water.

Answer--

The questions.

Set up--

Experiment to determine the freezing point of sea water with varying amounts of salt.

Answer--

The questions on Salt Water and Freezing.

Read--

Sea Ice Formation
The Frozen Seas

Answer--

The questions.

TEMPERATURE OF THE DEPTHS

Temperature		Depth	
* 87°F - 30°C	Mixed Layer	0 ft	0m
79°F - 26°C		300 ft	91m
70°F - 21°C		600 ft	182m
60°F - 16°C		1,200 ft	365m
50°F - 10°C		1,800 ft	548m
41°F - 5°C		3,000 ft	914m
40°F - 4°C		4,200 ft	1,280m
39°F - 3°C		6,000 ft	1,828m
* 35°F - 1°C		36,000 ft	10,973m

* These are summer temperatures. During winter shallow coastal water temperatures will vary significantly depending on surface weather conditions. Winter temperatures near edge of continental shelf will average between 70° - 75°F (21° - 25°C). These are Gulf of Mexico Temperatures.

* Temperature for deep ocean.

TEMPERATURE OF THE WATER

The area from the surface to a depth of 300 feet is referred to as the surface water. This water is affected by waves, wind, etc. Its temperature will vary far more than the deep water. The surface temperature will change throughout the year. The change will depend on the location. The sea surface temperatures are highest near the equator and lowest near the poles. The average surface temperature is about 16°C, but it varies from about -2°C to about 30°C. Sea ice, however, may have a temperature far below -2°C.

The temperature depends in part on the current patterns. Some currents transport warm water to high latitudes and others transport cold water toward the equator. The temperature patterns will change with the seasons. These seasonal changes tend to be greater in the mid-latitudes than at the poles or the equator.

The temperature of the deep water varies much less than the surface temperatures. The overall average temperature of the ocean is 4°C. This temperature occurs at about 1,600 meters at the equator, but reaches the surface at about 55° North and South latitudes. Water deeper than 3,000 meters is cold at all latitudes. Even at the equator, water near the bottom is very cold, about 2°C at 4,000 meters. At the poles there is very little change in temperature with depth.

Even though the surface temperature of the sea varies, it varies less than land temperatures. The surface temperature of the sea varies less because of the great heat capacity of water. As a result, the sea provides a fairly stable environment for marine life and is a moderating influence on the coastal climate. The temperature in the oceans is one of the factors that controls the distribution of marine organisms and the density of seawater.

Answer:

1. Why does the temperature of the surface waters vary?
2. Why is the temperature of the water different in the winter than in the summer?
3. What is the relationship between water temperature and depth?
4. Of what importance is the fact that the temperature of the sea varies less than land temperatures?
5. What will happen if the water temperature drops below 28°F or -1.9°C?

Set up an experiment to determine the freezing point of sea water with different amounts of salt dissolved in it.

Investigate frozen salt water.

1. Freeze some salt water in an ice tray.
2. Put the frozen salt water in tap water.
3. Explain what happens.

4. Taste some frozen salt water. Does it taste salty? Explain.

5. How do you expect the ice in ice bergs to taste?

SEA ICE FORMATION

When the ocean surface has cooled enough, microscopic ice crystals begin to form. As freezing continues, a slush forms which covers the surface like a wet blanket of snow. Eventually the crystals begin to grow downward. The ice crystals contain no salt, but there is brine (salt and water) in small spaces between the ice crystals. One kilogram (1000 grams) of newly formed ice consists of about 800 grams of ice (salinity ^{o}/oo) and 200 grams of seawater (salinity 35^{o}/oo). Therefore the average salinity of new formed ice is about 7 ^{o}/oo compared to 35^{o}/oo for seawater.

Salinity of newly formed sea ice depends on the temperature at which the ice formed. At a temperature near freezing, ice forms so slowly that brines can escape. Little seawater is trapped in between the ice crystals, so the salinity of ice is low. At lower temperatures, ice forms more rapidly and more seawater is trapped, so that the salinity is high. However the salinity of ice is always less than seawater.

As sea ice ages, salt is left out and the ice hardens. A layer up to 20 cm thick (about 8 inches) can form in one freezing season. Over many freezing seasons the thickness increases. The maximum thickness is usually about 2 to 3.5 meters (6 to 10 feet). When old ice melts, pools of drinkable fresh water form on the upper surface. These pools of fresh water have saved the lives of several polar explorers who ran short of drinking water.

THE FROZEN SEAS

The great ice sheets cover roughly 12 percent of the ocean world. All ice comes from the freezing of seawater. Seawater does not freeze as easily as fresh water; the more salt it contains, the lower the freezing point. The usual range for the freezing point of seawater is -1.9°C or 28° to 31°F while the freezing point of fresh water is 0°C or 32°F.

Primarily salt water freezes slower because the water grows more dense as it cools. As a result, the water sinks and is replaced by warmer water from below so the atmosphere has to cool the entire water/mass to -1.9°C before the surface water can freeze. This sinking is confined to the upper 300 feet, but even this is sufficient to ensure that the open oceans freeze much later than shallow inshore waters.

During freezing, salt is not part of the ice crystal, but is trapped in a network of tiny liquid brine cells from which it eventually escapes into the sea. New ice contains only some ten parts of salt per thousand while seawater contains some 35 parts of salt per thousand.

One of the most unusual sights in the ocean is a giant floating iceberg which broke from the end of a glacier or an ice sheet on land. A typical new berg weighs about 1.5 million tons, stands 260 feet out of the water and extends more than 1200 feet below the surface. By the time it reaches the Atlantic from the Arctic it has shrunk to 150,000 tons and wind erosion may have sculptured it into the form of a castle. Antaractic bergs form in the same way and are generally much larger than Arctic bergs , often more than 50 miles long.

1. Why does the open ocean take longer to freeze than the shallow waters?

2. Discuss the possibility of towing icebergs to desert regions as a source of fresh water.

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

A LITTLE SALT AND THE FORCE

Build--

A simple hydrometer and determine salinity according to the instructions in What is the Salinity?

Look at--

The chart on salinity of the Gulf of Mexico.

Locate--

The areas mentioned on the map of the Texas coast.

Answer--

The questions on salinity.

Read--

Why is the Ocean Salty?
The Force--Pressure.

Experiment--

With sea water and pressure.

Answer--

The question on pressure.

WHAT IS THE SALINITY ?

Hydrometers can be used to determine the salinity of water. You can make your own simple hydrometer from a plastic straw. Stopper one end with clay, then add some paper clips, thumb tacks, B.B's or toothpicks. Add enough weight so that the straw floats vertically in a salt solution of known concentration. Mark the water level on the straw. Dilute the salt water by 1/4 and again mark the level of the water on the straw. Repeat the dilution of the salt water and subsequent marking on the straw. These markings represent your salinity scale. You should be able to put this "hydrometer" into a salt solution of unknown concentration and estimate the salinity of the solution.

1. What causes the "hydrometer" to float higher in water with more salt?

2. What would happen to the "hydrometer" if it is put in fresh water?

3. How could you make your hydrometer more accurate?

A LITTLE SALT

From our testing activity we know that the ocean is salty. Salinity is the measure of the amount of dissolved salts in sea water. Changes in salinity are caused primarily by evaporation, precipitation, fresh water input from rivers and by mixing currents. The surface salinity of the oceans depends on the difference between evaporation and precipitation. These are the results we find in the Gulf of Mexico.

SALINITY OF THE GULF OF MEXICO

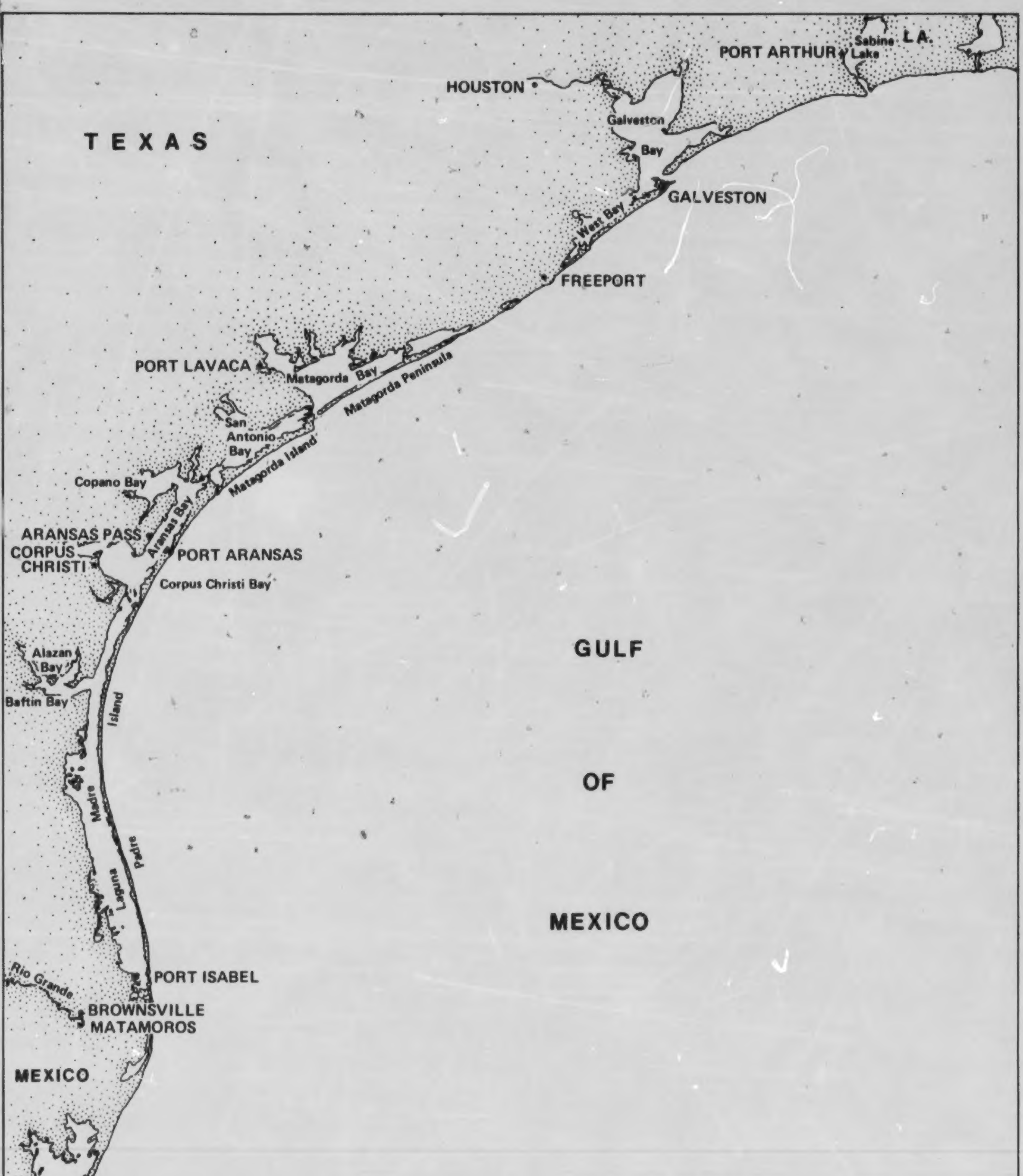
Area	Salinity (grams of salt per kilogram of water)
Over central Gulf of Mexico Basin	36.0 to 36.3
Edge of Yucatan Shelf	As high as 36.6
Several miles offshore from mouth of Miss. River	Less than 25,0
Oceans	Average 35

1. Why does the salinity vary? What factors would cause Laguna Madre (bay which extends from Corpus Christi to Port Isabel) to reach a salinity of 130 during droughts?

2. Will heavy rains increase or decrease salinity? Explain.

3. Why would the salinity several miles offshore from the mouth of the Mississippi River be less than the central basin area of the Gulf?

4. When would you expect the Gulf to have its highest salinity, mid-spring or mid-summer? Why?


TEXAS
HOUSTON
PORT ARTHUR
Sabine Lake
LA.
Galveston Bay
GALVESTON
West Bay
FREEPORT
PORT LAVACA
Matagorda Bay
Matagorda Peninsula
San Antonio Bay
Matagorda Island
Copano Bay
Aransas Bay
ARANSAS PASS
PORT ARANSAS
CORPUS CHRISTI
Corpus Christi Bay
Alazan Bay
Baffin Bay
Padre Island
Laguna Madre
PORT ISABEL
Rio Grande
BROWNSVILLE
MATAMOROS
MEXICO
GULF OF MEXICO

WHY IS THE OCEAN SALTY ?

The Brazos, Colorado, Rio Grande, Trinity, Mississippi and other rivers empty into the Gulf of Mexico. Other rivers empty into the Atlantic, Pacific and Indian oceans. The Gulf of Mexico and the oceans are all salty. Why aren't the oceans as fresh as the river waters that empty into them?

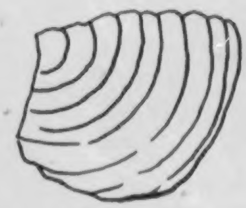
In the beginning when the oceans were first formed, they were probably only slightly salty. The first runs and melting of the snows on the young earth hundreds of millions of years ago began the process of breaking up rocks and carrying the minerals to the seas and the oceans became saltier. Therefore the ocean is salty because of gradual concentration of dissolved chemicals eroded from the earth's crust. These chemicals were washed into the oceans during geologic time. Solid and gaseous materials from volcanoes were also carried into the oceans. The salt also became concentrated in the sea because the sun's heat vaporizes almost pure water from the surface of the sea and leaves the salts behind.

It is estimated that the rivers and streams flowing from the United States alone carry 225 million tons of dissolved solids and 513 million tons of suspended sediment annually to the sea. Some scientists estimate that the oceans contain as much as 50 million billion tons of dissolved solids. If the salt in the sea was removed and spread evenly over the earth's land surface it would form a layer more than 500 feet thick -- about the height of a 40-story building. Throughout the world, rivers carry an estimated 4 billion tons of dissolved salts to the ocean annually. About this same amount of salt from the ocean water is probably deposited as sediment on the ocean bottom. The amount of salt that is deposited on the ocean floor as sediment is equal to the amount of salt added to the oceans by the rivers. Therefore the salt concentration of the oceans has stayed about the same in recent geological history.

The salinity of the ocean water varies. It is affected by such factors as melting ice, inflow of river water, evaporation, rain, snowfall, wind, wave motion, and ocean currents which cause horizontal and vertical mixing of the salt water.

Sea water is much saltier than the river waters. However sea water and river water are very different from each other in the salts that they contain. Sodium and chloride (components of table salt) make up more than 85 percent of the dissolved solids in ocean water, but they make up less than 16 percent of the salts in river water. Rivers also have more calcium than chloride, but the oceans have 46 times more chloride than calcium. Silica makes up a part of river water but not sea water. Calcium and bicarbonates make up nearly 50 percent of dissolved solids in river water but less than 2 percent in the ocean water.

Marine organisms have a part in determining the ocean water's composition. Many marine organisms extract chemicals from the sea water. Mollusks, crustaceans, coral, etc. remove calcium. Plankton remove silica. Some chemicals in the sea water do not seem to be affected by marine organisms. Chemical precipitation or physical-chemical reactions remove these chemicals. Although the composition of sea water differs from river water, the proportions of the chemicals in sea water are nearly identical in all the earth's oceans.



THE FORCE--PRESSURE

The pressure in the sea is the force with which water pushes on an object. The pressure increases with the depth of the water. At sea level, the pressure is one atmosphere or about 14.5 pounds per square inch. Pressure in the ocean increases by about one atmosphere (14.5 pounds per square inch) for each 10 meters of depth. At the depth of the Sigsbee Abyssal Plain in the Gulf of Mexico the pressure would be 360 times or 5228.8 pounds per square inch or 2.2 tons per square inch as much as near the surface. In the deepest depths of the oceans, the pressure reaches 14,000 pounds or 7 tons per square inch.

Instruments used to study the ocean must be able to withstand the pressure changes. One of the problems facing designers of submarines and submersibles is to construct them strong enough to stand the great pressures of the ocean depths.

Life exists at all depths of the sea and pressure is not a problem for most marine organisms since their structure is such that the pressure inside is equal to the pressure outside. However, chemical reaction rates may differ under various pressures and many organisms may be chemically adapted to life at a particular depth. Man is not adapted to live under pressure. One result of the increased pressure is that the lungs of a human diver tend to shrink with increasing depth. The pressure in the lung decreases so more gas is pumped into the lungs to equalize pressure inside and out. The fish have swim bladders and glands that secrete gas during the descent. Similarly divers may increase their depth range by carrying Self-contained Underwater Breathing Apparatus (SCUBA) from which they can get enough air to keep a balance between internal and external pressure. A diver at 20 meters experiences a pressure of three atmospheres or 43.5 pounds per square inch both inside and outside the lungs. So when a diver returns to the surface where it is only one atmosphere of pressure, the diver must continuously exhale to relieve the pressure or else the lungs might rupture.

Only divers in depths shallower than 60 meters (approximately 195 feet) are able to breathe ordinary air. Ordinary air is composed of about 78% nitrogen and 21% oxygen with traces of other gases including carbon dioxide. Oxygen is essential to life while nitrogen plays no part. Under high pressure nitrogen dissolves in the body and can make deep-sea divers dangerously ill, so using ordinary air at depths of more than 60 meters is not possible. Even the amount of oxygen that can be safely used varies according to depth. A diver going below 60 or 70 meters needs to breathe a mixture in which the percentage of oxygen is reduced and nitrogen is replaced by a less troublesome inert gas.

Under pressure, the inert gas in a breathing mixture dissolves in the blood and tissues. If the pressure is reduced too quickly during ascent to the surface, the inert gas will form bubbles which can cause serious illness by blocking veins and arteries. This illness is decompression sickness or the bends. The only way for a diver to avoid decompression sickness is to come up so slowly that the bubbles never form, or at least never get big enough to do damage. This greatly prolongs the dive. For example, if a man stays at a depth of 180 meters for only an hour his decompression will be 38 hours. A brief dive to 300 meters requires many days to return.

From a financial standpoint, the hours lost in decompression are costly. There has been a good deal of relatively recent research directed toward devising ways to increase the length of underwater working time in proportion to the time required for descending and ascending. The chief reason for this has been the offshore oil industry. As oil wells go deeper and deeper so must the divers who are needed for the processes of drilling and maintaining the equipment. This is a complicated problem, since the answers depend on the nature of the gas, the differing tissues and the many possible pressures and length of the dives. As a result of extensive work by many researchers all over the earth, we now have both compression and decompression tables for a wide range of possible dives.

What will divers be doing in the year 2000? Will they have overcome the present limits of depth, duration and mobility? How might their functions change if and when oil-field wellheads are in a depth of 1000 meters or more?

Answer

(1) As the depth of the water increases, does pressure increase or decrease?

(2) Why don't we feel the 14.5 pounds per square inch of pressure on our bodies at sea level?

(3) What would happen to our bodies if we stepped out onto the floor of the Abyssal Plain? (Pressure 2.2 tons per square inch) Why?

(4) Could the animals that live in the surface waters also live in the deepest areas of the ocean? Explain.

(5) What are some of the problems that pressure causes in relation to man's working under the sea?

(6) What are some ways that you think man may solve the problems caused by the pressures of working in the depths of the oceans?

SEA WATER AND PRESSURE

Look at a milk carton. Where would water pressure be the greatest--near the top or bottom?

Test your answer: punch 3 small holes in the sides of the carton, one near the botton, one near the middle and one near the top. Set the carton at the edge of a sink or pan. Put tape or fingers on the holes while another person fills the carton with water.

Open the holes (remove tape or fingers). What happens to the water? Sketch the results below.

Record the length the pressure pushes the water stream out and also the depth of the hole and graph the results.

Questions:

1. Why doesn't all the water stream out the same distance?

2. What do you predict would happen if you could have a taller carton with more water and had a hole near the bottom?

3. Discuss the effects of pressure on the SCUBA diver as he descends into deeper water.

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

DENSITY AND THE SEA

Read--

Density and the Sea.

Conduct--

An experiment to understand the importance of salinity and water density.

Answer--

The questions about the experiment.

Conduct--

An experiment to demonstrate the effect of temperature on the density of water.

Sketch--

The experiment and show the water movement.

Answer--

The questions on the effect of temperature and the density of water.

Demonstrate--

A two-layered system of water like the ocean.

Sketch--

The results of the demonstration of a water system like the ocean.

Answer--

The question on water movement and density.

Read--

Sea Water and Density.

DENSITY AND THE SEA

Another physical factor of sea water is density. Density is the mass of the sea water compared to an equal volume of fresh water at 4° C (39.2°F) and at one atmosphere of pressure. Whether a substance sinks or floats in liquid is determined by its density. A substance less dense than its surroundings tends to move upward; in other words, it floats. If its density is greater than its surroundings, it will sink. Factors controlling seawater density include temperature, salinity and pressure.

EXPERIMENT-IMPORTANCE OF SALINITY AND WATER DENSITY

Conduct an experiment to understand the importance of water density.

1. Fill a glass with fresh water from the tap.
2. Fill a medicine dropper with salty water, colored with food coloring.
3. Put a drop of colored salty water into a beaker (glass) of fresh water. The fresh water and salt water should be the same temperature.
4. Reverse the procedure: Put a drop of colored fresh water into a beaker of salty water.

Answer

1. What happens to the drop of salt water put into a beaker of fresh water?
2. What happened to the drop of fresh water put in salty water?
3. Which is more dense the salt or fresh water? Why?
4. What happens to the fresh water of a river flowing into the salty water of the Gulf of Mexico?

EXPERIMENT-THE EFFECTS OF TEMPERATURE ON WATER DENSITY

Conduct an experiment to demonstrate the effect of temperature variations on the density of water.

1. Place a beaker (dish) of water on a stand.
2. Place ice in the water on one side of the dish.
3. Heat the other side of the dish.
4. Add a small amount of ink or food coloring so the water movements will be more visible.
5. Make sketch of the experiment. Add arrows to the sketch to show the direction of the water.

Answer

1. Is ice more or less dense than water?
2. Does the warmed water rise or sink?
3. Does the cooled water rise or sink?
4. Which water will sink, the more or less dense water?
5. Which water is the more dense, water from the north pole or the equator?
6. As water from the north pole moves south would you expect it to sink or rise?

DEMONSTRATION OF A WATER SYSTEM LIKE THE OCEAN

Conduct an experiment to demonstrate a two-layered system like the ocean.

1. Dissolve as much salt as the water in a half filled container will hold to make dense salty water. (Add salt until some remains undissolved after vigorous stirring.)
2. Carefully pour fresh water on top of the salty water. After the water movements caused by adding the fresh water layer have stopped, you should have a two layer system where dense salty water lies below the fresh water.

3. Use the medicine dropper to add a drop of slightly salty colored water to the fresh water. Observe the results.

4. Use an eye dropper to add a drop of slightly saltier colored water down into the very salty water. Observe the results.

Complete a sketch of the results by showing how the drops moved from each dropper.

1. Which water mass will sink, the more or less dense water?

2. Does sea water become more or less dense when the salinity is decreased by adding fresh water?

3. Will the water from the Mississippi River stay on top or sink as it flows into the Gulf of Mexico? Why?

4. Would the water from Laguna Madre during the summer (higher salinity than the Gulf of Mexico) stay on top or sink as it enters the Gulf of Mexico? Why?

5. Make a statement relating density of the water to the movement of the water masses.

SEAWATER AND DENSITY

Almost all movements of water in the deep ocean are caused by differences in density. The density of seawater may vary only slightly but these differences may cause changes in the movement of whole water masses. Therefore, density is of great interest to oceanographers in the study of currents.

From your experiments you have learned that seawater density is increased by increasing the salinity. Seawater behaves like most materials in that it becomes less dense with increasing temperature. If salinity is constant then the less dense seawater will generally be the warmest and occur on top. No general pattern of increase or decrease in salinity with depth is observed. There are regions of maximum and minimum salinity which indicate the presence of deep ocean currents. These currents caused by increased density result primarily from low temperatures rather than high salinity.

Water makes up the major part of plant and animal cells, therefore, the density of the marine organisms is nearly the same as the water in which they live. Since their density is similar to the water around them, the organisms can be supported in the water or float. Howver, some plants and animals float on the surface or regulate their buoyancy with the help of gas-filled bags or sacs. When they fill the sac with gas, they become less dense and move up in the water. If gases are removed from their sacs they become more dense and sink lower into the water.

TOPIC FOUR
THE PHYSICAL CHARACTERISTICS OF THE OCEAN

IT MOVES!

Read--
Currents.

Look at--
Diagram of main ocean currents.

Answer--
The question on currents.

Color--
The warm currents on the diagram red and the cold currents blue.

Use--
A World Almanac and look up the annual winter and summer temperature of several cities near warm and cold currents.

Discuss--
Your results.

Read--
Surface currents in the Gulf of Mexico.

Read--
Diagram of surface currents in the Gulf of Mexico.

Discuss--
How the currents differ with the season.

Look at--
Tides.

Demonstrate--
How tides are formed.

Demonstrate--
How the sun and moon affect tides.

Read--
In and Out--The Tides.

Answer--
Questions on tides.

Optional

Read--
"Young Naturalist: Tides" Article in Texas Parks & Wildlife, November, 1974, pp. 29-31.

Read--
Waves.

Experiment--
To determine the causes of waves.

Demonstrate--
Waves move but not the water.

Read--
Catastrophic Waves.

Illustrate--
The different types of waves, tides and currents through dances.

CURRENTS

The ocean's waters are constantly moving. If you sail or swim in the ocean, you know about the movements, or currents, of waters. Some currents affect only a small area, such as a beach. These are the ocean's response to local, often seasonal, conditions like rainfall. Other currents are permanent and involve large parts of the ocean. There are two main types of currents: surface currents and deep ocean currents.

The main cause of the surface currents is wind. Once the current's movement is started other factors may affect its drift. One is the friction caused by neighboring water masses or the sea floor. These tend to slow the current down. Another is the deflecting force of the earth's rotation - the Corialis effect. As the earth rotates, points on the equator travel faster than points near the poles, so an object moving tends to speed "ahead" of the earth beneath it, while an object moving from pole to equator gets "left behind." In effect, this means that objects moving in the Northern Hemisphere always curve to the right (clockwise) and objects moving in the Southern hemisphere curve to the left (counterclockwise). Our present knowledge of the currents in the ocean surface layer is reasonably good. This knowledge is largely the result of the determination of ships' positions by many generations of sailors. They correctly assumed that the difference between the ship's predicted position and actual position was due to currents.

Some currents have definite boundaries in which they flow through the ocean. These we call streams, since they are like rivers of waters moving along regular routes. (Look at the drawing of the major ocean currents.) The Gulf Stream current is an example. It is warmer than the surrounding ocean since it originates near the equator. It has a definite effect on land temperatures-warming them. The stream begins as a result of temperature, low pressure and wind action. Heating near the equator causes the water to expand and move northward in a well-defined stream into the Gulf of Mexico through the Yucatan Channel. Part of it then leaves the Gulf of Mexico and flows along the Atlantic coast.

Deep Ocean Currents

The currents we have been discussing so far are produced by wind. They are in the surface water, although the Gulf Stream carries water at depths of 1,500 meters or more. Water movement in the

the surface currents is basically horizontal. Deep ocean currents, however, move both horizontally and vertically, extending into the deepest parts of the oceans. They are caused by the differences in the density of the water. Eventually the deep water is inseparable from that at the surface. Even deep water is returned to the surface and becomes part of the surface currents, and eventually sinks to rejoin the deep circulation.

The deep currents are responsible for carrying oxygen into the deepest parts of the oceans. This allows marine organisms to live at all depths. Deep currents also bring nutrients from the sea floor to the surface. If it were not for these deep currents, the oceans would be stagnant and without oxygen in the depths. If these currents did not bring nutrients from the bottom to the surface, the surface productivity would be less rich.

The deep ocean currents are very slow compared to the surface currents. Sometimes they move only a few centimeters per second while it is common for surface currents to have speeds of 50 to 100 centimeters per second. Speeds of 300 centimeters per second have been observed in the Gulf stream. Estimates are that it has taken about 750 years for water to travel from the surface in the Antarctic to the bottom of the North Atlantic Ocean. It takes about 1,500 years for water to travel from the Antarctic to the North Pacific. Because of their slow speeds, deep currents are more difficult to study directly.

If the density of the ocean water were the same everywhere there would be no deep ocean currents. If denser water from increased salinity of cooling is introduced at the surface, it will sink until it reaches a level at which its density equals the surrounding water.

The Currents and Man

The currents affect our lives in many ways. One important role they play is in influencing the world's climate by moving large masses of warm water to cold latitudes and cold water to warm latitudes. The climate of the eastern United States and western Europe is far milder than that elsewhere in the same latitudes because the Gulf Stream moves warm water past its shores. The California current keeps northern California, Oregon and Washington not too hot in summer and not too cold in the winter. The currents are also useful in weather production. In navigation, knowing and following the currents has allowed ships to travel across the oceans faster. A straight line across the ocean is not as fast as following the currents. Ocean circulation also brings nutrients to the surface waters. If this did not occur the oceans would be nearly lifeless. The differing temperatures also act as barriers to some fish. The currents also may transport tiny floating plants and animals in areas where they would not normally occur, such as the slope organisms in the Sargasso Sea.

The currents have played a role in history. Explorers followed them. Ponce de Leon used the Gulf Stream. Ben Franklin used knowledge of currents to get mail shipped between England and the United States faster. It is very possible that the currents have affected the movement of people. Examples of this are: the Incas of Peru to the Easter Islands (Thor Heyerdahl - Kon Tiki) and the Mediterranean culture to the Americas (Thor Heyerdahl - Ra Expeditions). The currents also affect the movement of pollutants.

1. Where do most of the major ocean currents begin? (Use sketch of major ocean currents.)

2. Is the temperature of the water warm or cold where the major currents begin?

3. In what direction do the major currents move in relation to the equator? In the northern hemisphere? In the southern hemisphere?

4. What happens to the temperature of the currents at the pole regions?

5. Once the currents reach the poles in what directions do they move?

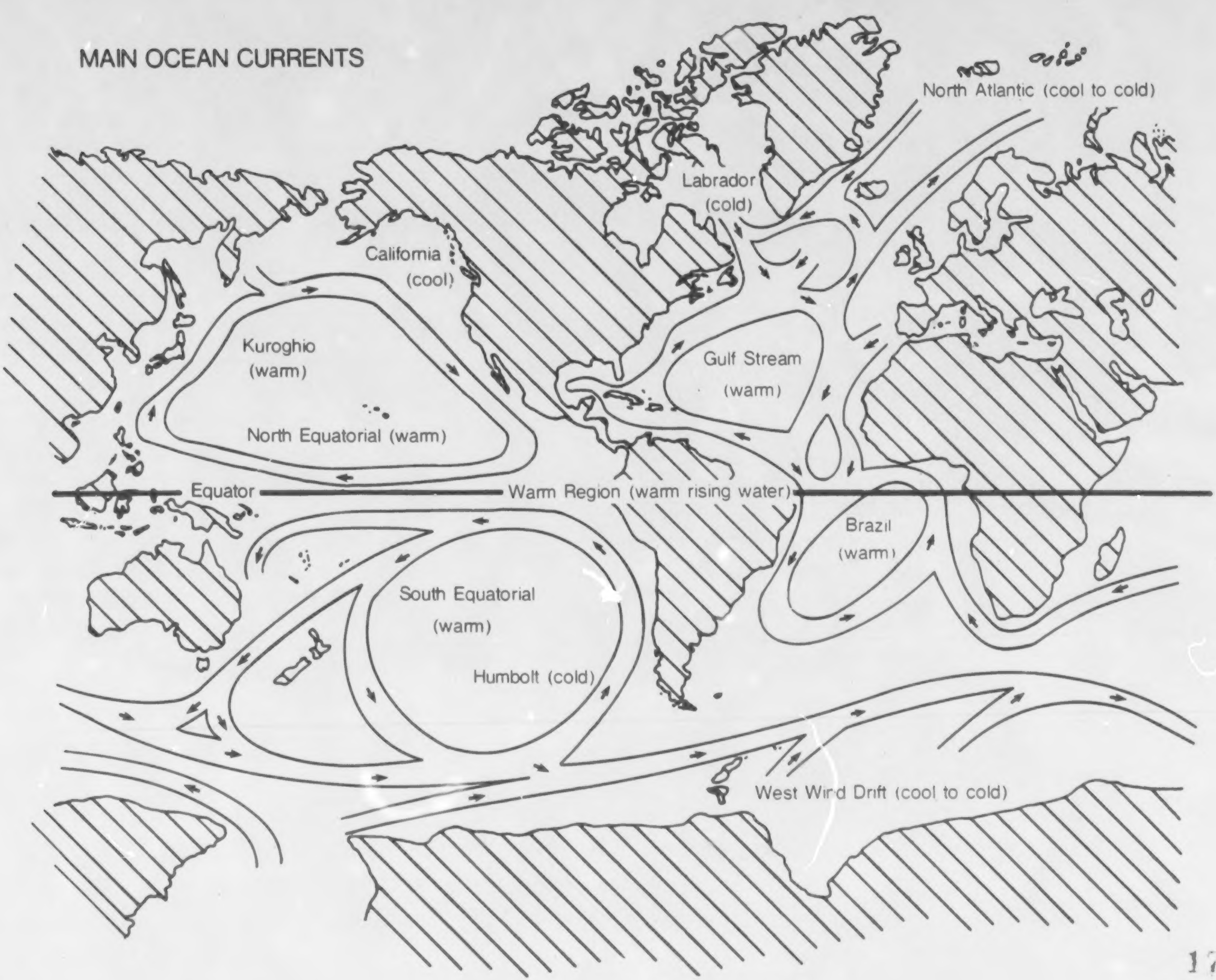
6. What effect would the Gulf Stream current have on the land nearby?

7. In the summer, San Francisco boasts that it is an "air-conditioned" city with temperatures of 59° and 63° F in July and August. Explain why.

8. How could knowledge of the ocean currents benefit us in the future?

9. Use the sketch of the major currents. Discuss the possible role of currents in bringing people from one area to another part of the world.

MAIN OCEAN CURRENTS



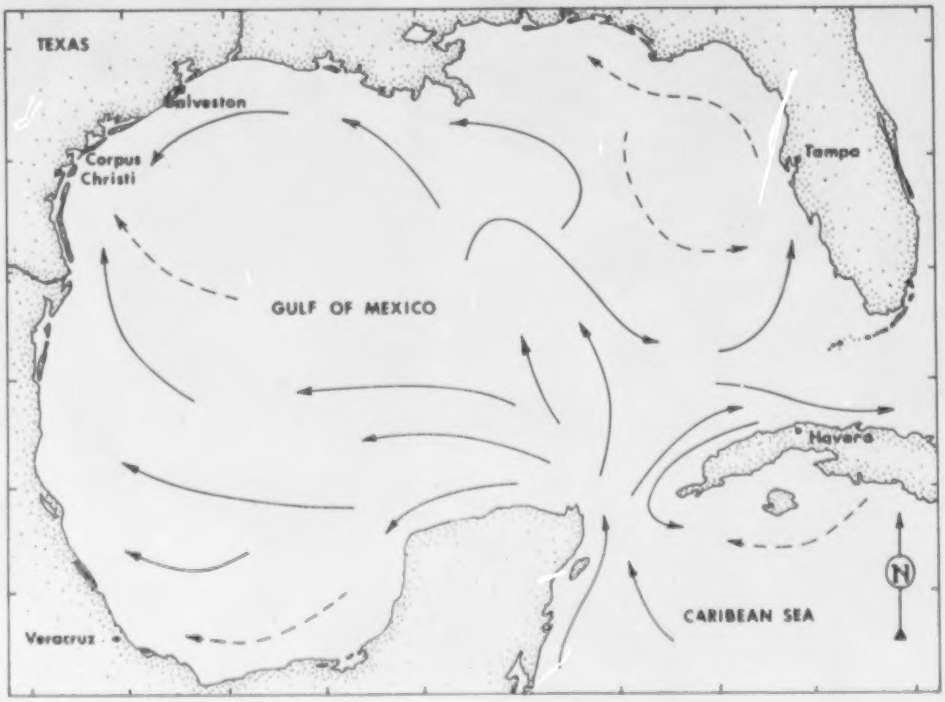
North Atlantic (cool to cold)
Labrador (cold)
California (cool)
Kuroghio (warm)
Gulf Stream (warm)
North Equatorial (warm)
Equator
Warm Region (warm rising water)
Brazil (warm)
South Equatorial (warm)
Humbolt (cold)
West Wind Drift (cool to cold)

SURFACE CURRENTS IN THE GULF OF MEXICO

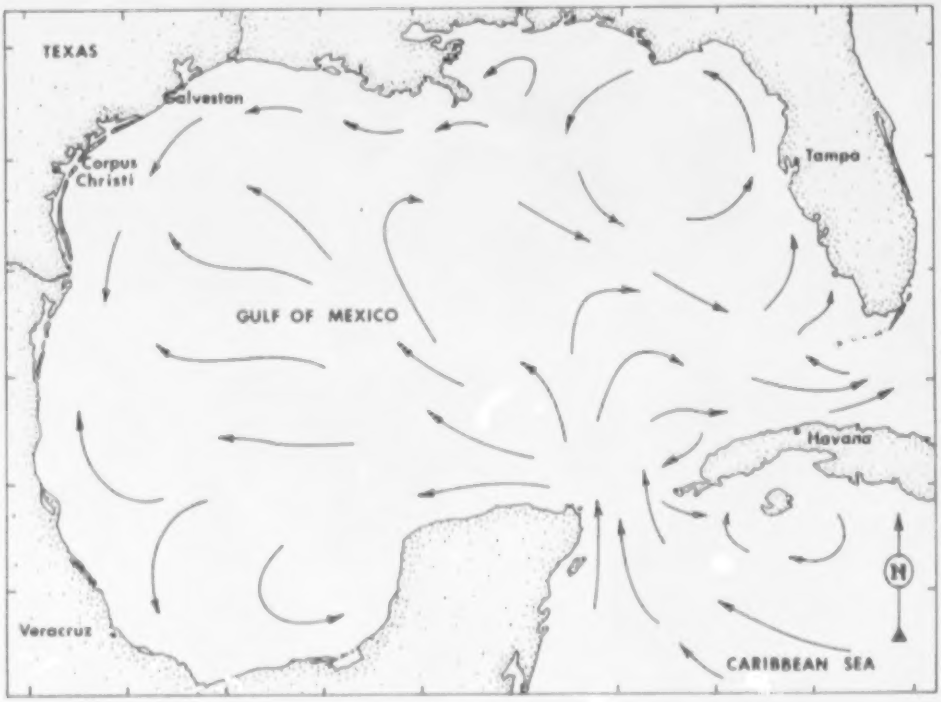
Inshore currents are of concern although they have not been studied in detail. It appears that the Mississippi current follows the coast southwestward, getting narrower toward Mexico. It is the principal force controlling productivity along the Texas coast. Since it carries the sediments from the Mississippi River it is responsible for the muddy nutrient-filled waters off the Texas coast.

The Gulf of Mexico can be divied into two major circulatory divisions, east and west, each of which has a different flow pattern. Water enters the Gulf (see diagram of currents of Gulf of Mexico) by the Ucatan Strait and leaves by way of the Florida Strait. The general circulation pattern consists of a clockwise loop current flowing from the Yucatan to the Florida Strait. There are no strong permanent currents in the western Gulf. Large current rings, or eddies, form from the loop current. Thus, the eastern Gulf is dominated by one major current and occasional rings. The western Gulf seems to be characterized by minor currents which change from winter (more definite) to summer (more variable).

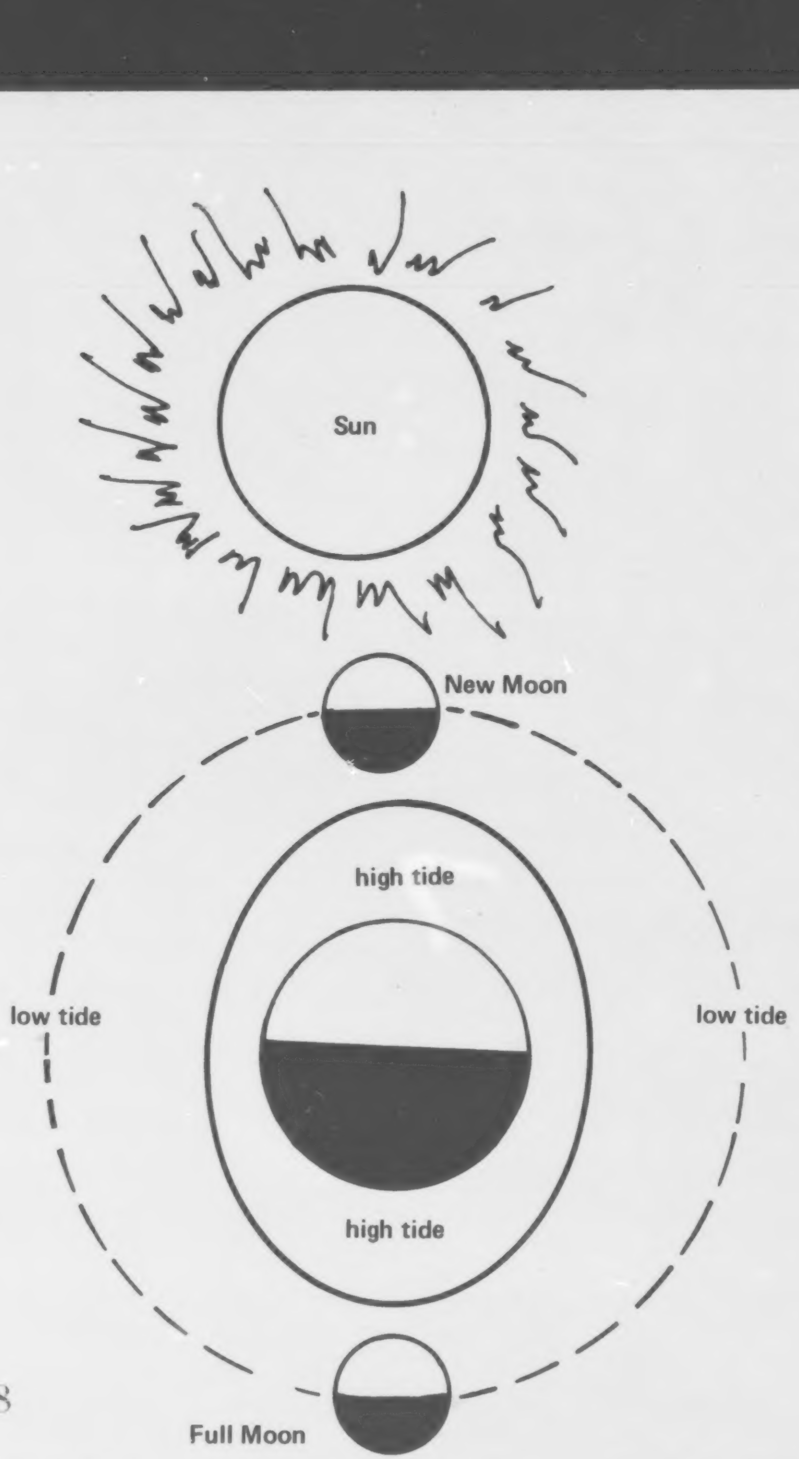
There is still much to be learned about the currents off the shores of Texas. There is only a slight and slow exchange of water between the Gulf and its neighboring bodies of water (Atlantic and Carribean), however, which results in a higher salinity level in the Gulf of Mexico.


TEXAS
Galveston
Corpus Christi
Tampa
GULF OF MEXICO
Havana
N
CARIBEAN SEA
Veracruz

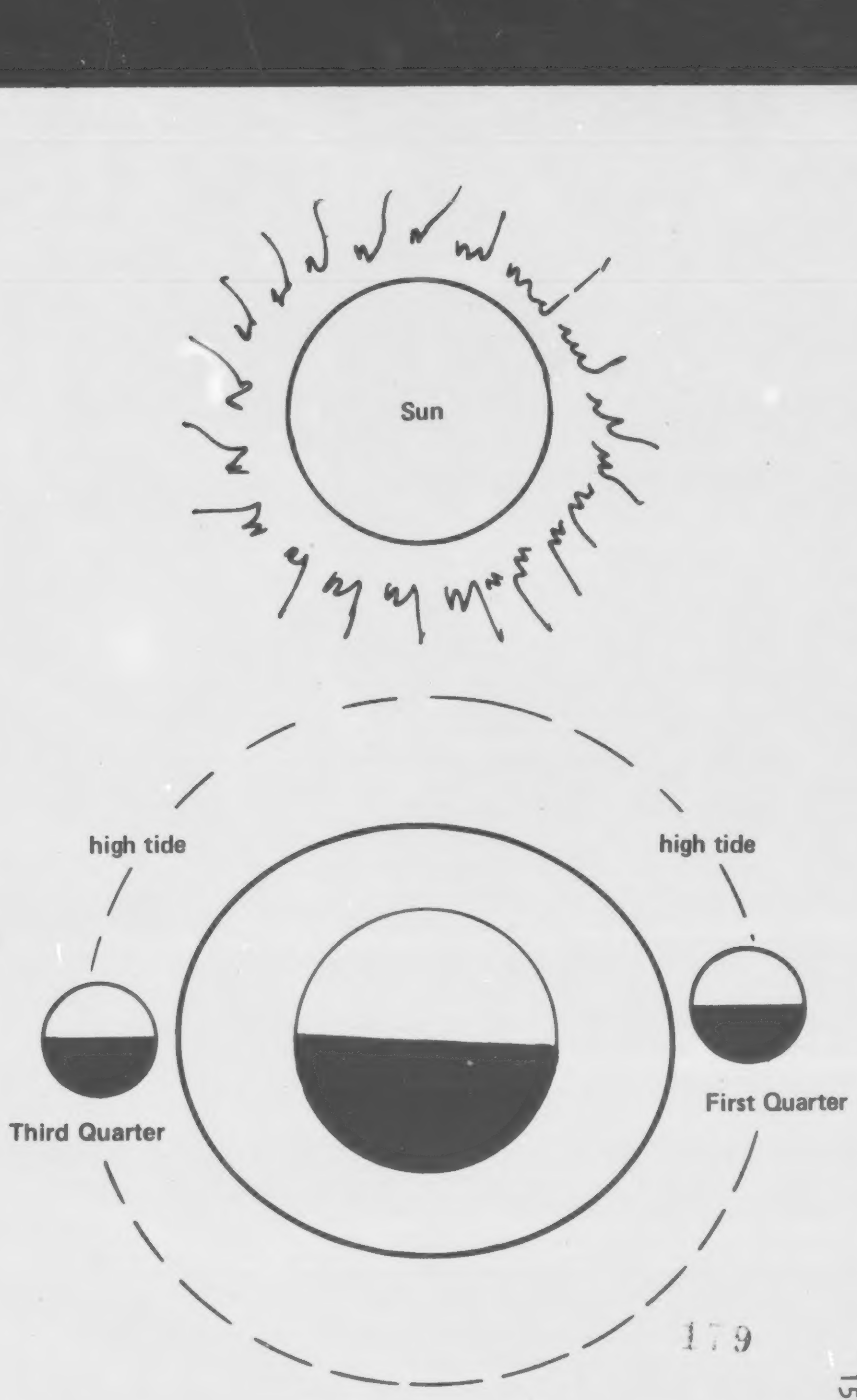
Surface Currents of Gulf of Mexico - August


TEXAS
Galveston
Corpus Christi
Tampa
GULF OF MEXICO
Havana
N
Veracruz
CARIBBEAN SEA

Surface Currents of Gulf of Mexico - February


Sun
New Moon
high tide
low tide
low tide
high tide
Full Moon

178


Sun
high tide
high tide
Third Quarter
First Quarter

179

HOW TIDES ARE FORMED

Place iron filings (representing sea water) in a glass jar. Place two magnets (one larger than the other) in different positions around the jar to represent the moon and sun. The larger magnet representing the sun should be farther away. Rotate the magnets around the jar.

1. What does the pull of the magnets represent?
2. Why does the smaller magnet cause more attraction of iron filings?
3. What happens when the magnets are in line on the same side of the jar?
4. What happens if the magnets are in line on opposite sides of the jar?

To demonstrate the pull of the sun and moon on the earth's water you will need a small world globe (earth) or medium size ball; small ball (the moon); large ball (the sun); two pieces of string, one long and one short; a large rubber band. Tie the pieces of string to the opposite ends of the rubber band. Tie the short piece of string to the small globe. Tie the long strong around the large ball.

Have one person hold the small ball and another student hold the large ball. First pull the small ball (moon) away from the globe. Observe what happens.

1. What do the strings represent? ____________________________
   What does the rubber band represent? ____________________
2. What happens to the ocean when the moon is pulled away?
3. What causes low tides?
4. Which tide is higher, the one on the side of the moon or the one on the side of the sun?
5. Which has the least effect on ocean water, the moon or the sun?

IN AND OUT--THE TIDES

Some of you live in the interior and you may scarcely have heard of tides. Those of you who live along the coast know very well what tides are and how important they are. Tides also behave like waves, but are so large that their wave-like characteristics are easily overlooked.

What are tides? Tides are one of the factors that keep the ocean in motion. They may be simply explained as waves that occur every twelve hours and 25 minutes. They have a wave length of half the circumference of the earth or approximately 12,600 miles. Their crests are high tides and the troughs are low tides.

Tides are the response of the ocean waters to the pull of the moon's gravity and to a lesser degree, the more distant sun's gravity. Looking at the sketches we see that the part of the ocean closest to the moon is pulled by the moon's gravity causing a "bulge" in the ocean. At the same time, on the opposite side of the globe, the centrifugal force caused by the rotation causes a "bulge" at a point farthest away from the moon. So high tides are caused on opposite sides of the earth. Between the two bulges, the water is drawn toward the earth by its gravity, causing a flattening or low tide. As the earth continues to rotate, water recedes from the original bulge and moves to other parts of the ocean.

When the sun is aligned with the moon, at times of a new moon and of a full moon, the gravitational force of the moon and sun act together to produce the highest tides called spring tides. They occur in all seasons of the year. When the moon and sun are at right angles to each other (when the moon is in its first and third quarters), the gravitational pull of the moon and sun work against each other causing tides lower than usual or neap tides.

Another factor that affects tides is the shape of the basin (shoreline and bottom shape). Winds and pressure also affect the tides. The Gulf of Mexico has all three types of tides, but responds better to the daily forces. The tides in the Gulf of Mexico, because of the basin shape, are mixed. This means some days there are two high and low cycles, others only one, others, one high and two lows and still others, two highs and one low. The average tidal range in the Gulf is small, being only one or two feet at most coastal stations. This may not sound like much, but on a fairly flat beach, the water can move onto shore 20 feet of more. The greatest range of the tides - about 54 feet (16 meters) - occurs at the head of the Bay of Fundy in Novia Scotia.

Tides carry in materials and organisms, so that during high tide, the streams and marshes are filled with life. Fish enter to spawn and feed. They move out with the lowering water. At low tide mollusks, such as oysters, clams and snails, are left behind in the mud where shore birds feed on them and the leavings of fish.

Tides also aid in distributing plankton. If it weren't for the tides, these minute life forms which are the basic food of all marine life would not be available for other organisms.

If it weren't for tidal flows, many of the pollutants would be trapped to accumulate and eventually poison the coastal area. However, as the tide flows out, these materials are carried out to sea.

The tides have been a moving force for as long as waters have covered the earth. Man has used this natural force to help him in many ways. Early sailing ships used outgoing tides to start them on their trips. People who lived along rivers would block off pools at high tide to trap fish. At low tide, they could easily catch the trapped fish. Man has found that tides will deposit good land for farming. Man has found still another use for tides; they are harnessed to produce electricity in power plants.

1. What can happen to ships if a seaman fails to check his tide tables?

2. You are going fishing on the coast. Could knowing the time of high and low tides by helpful to you in catching fish? Explain.

3. At which time level would you have the best luck beachcombing.

4. Explain why tides are important to our estuaries, bays and marshes.

5. Could the tides be a source of energy? Explain.

WAVES

We are by nature wave watchers. We would like to learn the ways of waves by watching them but we cannot because they set us dreaming. Try to count a hundred waves sometime and see.

Waves are not always dream producing. They are important to us in many ways, however. They make and remake ocean beaches each year as they entertain millions of sunbathers, surfers and swimmers. Waves from a single storm can kill hundreds of people and cause millions of dollars in damage to low-lying coastal areas. And waves must be considered in the design and construction of docks, breakwaters, groins and jetties; because they can cause the failure or destruction of these structures. Nor can waves be neglected in designing or operating ships

They may appear low and regular or high and frightening. Waves differ in size and form. Since waves are caused by the wind and the wind is irregular so are the waves. The size of the waves raised by wind depends on the wind's speed, the amount of time it blows, and on the size of the ocean surface it acts on. Wave motion is largely surface and decreases rapidly with depth.

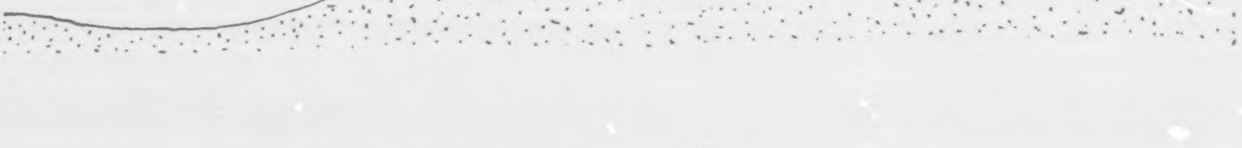
As a wave approaches the shore, which it does at an angle, the drag of the bottom causes it to rise higher until it tumbles over on itself or breaks. (The shore trips up the wave and it spills head over heels onto the shore.) The breaker rushes to the beach until its energy is gone. Obviously, waves in the Gulf of Mexico do not compare in size to those of the Pacific coast. Ours is a gently sloping beach and the waves spill forward. A steep bottom causes the waves to leap into a plunging wave and produces a crashing surf. The sloping bottom of the Gulf of Mexico does not produce the type of wave that surfers love to ride. Ours is a wide surf zone with a series of sand bars and troughs that have big breakers on the outer bar and smaller ones on each succeeding bar toward shore. In the closed bays and lagoons of the Gulf coast, there is almost no surf. Surf height depends on the height and steepness of the waves offshore and

Waves stack up water on the beach. This water does not go back as a wave but as a small stream or current. These are rip currents and they go out 300 to 400 feet from shore. The water in the rip current may travel as fast as 3 or 4 miles per hour. Often when a swimmer gets caught in a rip current, he will try to swim toward shore only to find that the current is carrying him out to sea. One can get out of the rip current by swimming parallel to the shoreline since the current is not very wide.

A shell collector may wonder why on some days he finds greater numbers of the right valves of clams and other days the left valves. This is a result of wave action and shell shape. Waves approaching from the right as you face the sea tend to deposit right valves.

1. What conditions produce the waves a surfer loves?

2. How does the water which the waves bring in move back out?



MAKE WAVES

Set up an experiment to determine the cause of waves.

1. Fill a pan ½ full of water.
2. Blow into a straw over the surface.
3. Observe what happens as you blow harder.

Answer Questions:

1. What was formed as you blew into the straw over the surface of the water?

2. What effect did blowing harder have on the surface of the water?

3. What blows across the surface of the ocean water?

4. Can it form waves? Explain.

5. What kind of waves would a storm cause? Why?

MAKE WAVES AGAIN

Set up another experiment to determine the cause of waves.

1. Using the same pan of water, place the pan on a desk or chair.
2. Pound lightly on the desk underneath the pan.
3. Pound heavily on the desk to show the effect of sea floor disturbances like earthquakes, volcanoes, etc.
4. Observe the results.

Answer:

1. What happened as you pounded on the desk?

2. What effect would these waves have as they reach the beach?

3. Could we harness waves as a source of energy? Explain.

WAVES MOVE BUT NOT THE WATER

Set up an experiment to demonstrate that the water itself is not traveling ahead.

1. Drop a small stone in a pond or large container of water (such as an aquarium, the larger the better) and watch the waves.
2. When the water is still again, place a cork or piece of paper in the water. Drop another small stone in the water. Observe the cork.
3. How does the cork move?
4. Repeat the experiment and watch the cork closely. The cork will bob up and down, backward, forward and down as each wave passes under it.
5. Water particles are moving in a circular pattern or back and forth in an elliptical pattern, but they are not moving forward. What is being passed on is the motion itself. This is a chain reaction much like a row of dominoes falling down in succession after one is pushed.

CATASTROPHIC WAVES

When the ocean is most spectacular it is often most dangerous too. The tsunamis are awesome and destructive. The tsunamis are commonly called "tidal waves." They are misnamed since they have nothing to do with tides. These seismic sea waves are caused by sea floor disturbances mostly earthquakes, faulting, submarine landslides, or volcanic eruptions. Tsunamis can have extremely long wavelengths of over 100 miles and can travel thousands of miles at speeds of over 200 miles per hour. Since the time between waves may be 10 minutes to an hour, they are unnoticed in the open ocean and cause no damage to ships. Because of their size when they begin to drag bottom in shallow water and break on shore, they can achieve incredible height and destructiveness.

A tsunami is not a single wave, but rather a series of waves which may persist for hours. The first motion may be either the advance or withdrawal of water. The first lowering of water may be like a very low tide followed by a large wave. The most destructive waves, however, arrive in the first four hours.

Tsunamis are most common in the Pacific since earthquakes are more common there. They have occurred in all oceans. Although they cannot be prevented, they can be predicted and death and damage to property can be minimized.

Storm surges, also known as storm waves or storm tides, are caused by the strong and steady winds associated with hurricanes or other severe storms. In storm surges, the winds simply pile up water against the coast. The rise in water level is greatest in partially enclosed bodies of water like the Gulf of Mexico. First comes a gradual change in water level, a few hours ahead of the storm's arrival. About two hours before the storm arrives, the sea level drops. When the hurricane passes, it causes a sharp rise in water level called the surge. The water level could rise 13 feet in 45 minutes. This could be greater if it occurs at high tide. The surge will persist for up to six hours and then the sea will return to normal. Approximately 12 hours later there will be another rise in sea level one-half to one-third as high as the original surge. In 1900, the hurricane storm surge which hit Galveston killed about 2,000 people. The disasterous storm surge that covered Bangladesh in 1970 is estimated to have killed over a half million people.

In addition to flooding coastal areas, these types of storms generally have very strong winds and heavy rain. This makes evacuation efforts very difficult.

SAY IT WITH A DANCE

It is not surprising that the sea, and especially the rhythmical movement of the sea has been an inspiration to the choreographer. Threnody, Pineapple Poll, Lady from the Sea, Sea Shadow and Water Study are but a few of the numerous ballets which get their imagery from the sea.

Try to imitate the motion of the waves and the movement of the surf onto and from the shore. Try to feel the sea with your whole body, as dancers must. To do this is to understand something very basic about the movement of water that can mean more than reading about it. See if you can illustrate the different types of waves, tides and currents through dance movements. You may want to use ballet or the current dances (rock, western or disco styles or invent your own). You may even want to use music with your dance.

List the types below. Then spend some time thinking of the type of dance or movement for each. What feelings does it show?

Type (waves, currents, tides)	Your dance for them

TOPIC FIVE
SEA INTERACTS WITH THE LAND

ACTIVITY ONE--Texas Coastal Climatic Zones
ACTIVITY TWO--Tropical Storms and Hurricanes

Materials for Classroom Use:

The Gulf of Mexico interacts with the Texas Coast/reading
Terrian and Climatic Interactions of the Gulf/drawing
Texas Almanac
El Niño/reading
Hurricane!/reading
Spectacular Agent of Change/reading
Hazardous Sea Warnings/reading
Hurricane Tracking Map
Hurricane Flooding/reading
Hurricane storm surge/activities
How Would You Prepare for a Hurricane?/activities
Hurricane Safety Checklists

Major Objectives for the Topic:

After completing the activities the student will be able to:

1.5 analyze the effect of the Gulf of Mexico on the climatic zones of the Gulf coast region;
1.5 discuss the effect of the extraordinary climatic event of hurricanes on the coastal zone;
1.5 compare and contrast several hurricanes that have hit the Texas coast;
1.5 compare and contrast the climatic zones of the Texas Gulf coast;
2.7 cite examples of the influence of the climatic conditions on man's activities;
2.7 relate occupations to the climatic zones;
3.1 discuss preparations in the event of a hurricane;
3.1 cite reasons why some form of coastal land use management can reduce exposure of lives and property to a hurricane.

Teaching Suggestions:

The purpose of this lesson is to present information to the student and to get him to start thinking about the effect of water on the climatic conditions of the land. He will also receive information on tropical storms and hurricanes.

1. Have the students complete the readings and respond to the questions.

2. After dealing with the readings and drawing, have a class discussion on the questions. Encourage students to generate related questions and then strive to answer them cooperatively.

3. You might have the students watch the weather forecasts and reports to note the effect that the air mass over the Gulf of Mexico has on the weather of Texas and the Mid-west.

4. Have the students use the Texas Almanac (most school libraries have copies) to look up counties in which Port Arthur, Galveston or Houston, Port Lavaca, Corpus Christi and Port Isabel are located to determine the annual rainfall, length of the growing season, agricultural products, businesses and industries. From this information and the drawing (Terrain and Climatic Interactions in the Gulf) they should determine that the rainfall in the Port Arthur area is more than twice that of the Port Isabel area. The lower coast has more windblown sand since there is less vegetation covering it. The lower coast will also have bays of a greater salinity due to decreased rainfall and increased evaporation. This affects the plants and animals of a region which, in turn, affects the agriculture and some of the businesses of the region. It points out the relationship of the climate to the agricultural products and the jobs available. You might have your students look up additional coastal counties. You might also have your students look up counties further inland to determine the effect of the Gulf on the climate of the coastal counties and how this effect decreases as one goes further inland.

5. The El Niño reading is an example of how the ocean affects the atmosphere and affects the weather. It also illustrates our need to know more about these interactions in order to predict and understand weather and climatic conditions.

6. The article "What's Happening to Our Climate?" (National Geographic Vol. 150, No. 5 (November 1976) pp. 576-615) has additional information and can serve as a resource for further discussion of the relationship of the oceans and the climate of the earth.

7. Much of the information for this section was obtained from the following sources: Hurricanes on the Texas Coast, Texas A&M University Sea Grant College Program, Publication number TAMU-SG-75-504, 48 pages, free from: Texas A&M University Sea Grant College Program, College Station, Texas 77843. Maps of areas covered by storm surges of previous hurricanes. "Hurricane Awareness Program Materials" may be obtained from the Texas Coastal and Marine Council, P.O. Box 13407, Austin, Texas 78711. These materials include maps showing the extent of storm surge flooding from past hurricanes for the following areas: Brownsville, Kingsville, Corpus Christi, Port Lavaca, Bay City, Galveston, and Beaumont. Storm evacuation maps may be obtained from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Distribution Division, C44, Riverdale, MD 20840. These maps, $2 each, are large scale and cover a small area in great detail. Specify the location for the map requested. Maps are available at this time for the following areas:

Alvin
Anahuac
Aransas Pass
Beaumont
Corpus Christi
Freeport
Galveston
Houston
Port Arthur
Refugio
Rockport
Winnie

Information on an area's land elevation should be available from the local city engineer. The engineering office in a Drainage District also has the information. The U.S. Department of Agriculture--Soil Conservation Service (USDA-SCS) can supply the information for rural as well as urban areas. There are SCS offices in the following cities:

Anahuac
Angleton
Bay City
Beaumont
Edinburg
Edna
Harlingen
Houston
Kountze
Liberty
Port Lavaca
Raymondville
Refugio
Robstown
Rosenberg
San Benito
Sinton
Victoria
Wharton

Natural Hazards of the Texas Coastal Zone a comprehensive atlas. Available from: Bureau of Economic Geology, University of Texas Box X, University Station, Austin, Texas 78712 ($3.15)

8. If you teach in the coastal area, you may want to use a contour map of the area to determine the effect of different storm surges. Locate the school, students' homes, etc. You can help determine areas which will be less likely to flood.

Before having your students complete the hurricane safety checklists, determine which students have actually been in a hurricane and have them tell the class of the experiences. As an alternative, have students interview individuals in the community who have experienced a hurricane.

Have the students complete the Hurricane-Safety Checklists and share them with their families. Since maybe a third of the people living in the coastal area have not experienced a hurricane, the students could conduct a survey to determine the community's hurricane awareness and help educate the community by sharing the checklists and discussing them with the people they interview.

You may also have the local civil defense office or local officials in charge of planning and coordinating evacuation, etc. during a hurricane present this information to the class or even the school. You can have your students develop plans to coordinate community education hurricane awareness programs and plan the action to take in case a hurricane hits the community. This plan should include the action before the hurricane arrives, during the hurricane and hours, days and weeks after the hurricane has passed.

9. The following publications are available at a nominal cost from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (When inquiring about the price of a particular title also include the adjacent "NOAA/PA" number.) Those publications marked by an asterisk (*) are available in limited quantities without charge from the Disaster Preparedness Staff, NDAA National Weather Service, Silver Spring, Maryland 20910.

Hurricane, The Greatest Storm on Earth (NOAA/PA 76008) A two-color, 24-page booklet describing the incidence and general causes of hurricanes, their structure, dynamics, and destructive effects. The work of the hurricane center and the hurricane warning service is described.

Hurricane Warnings (NOAA/PA 77001) A two-color, 16-page booklet for approximately fifth grade level. Using the cartoon character, "Owlie Skywarn," it describes the hurricane, its destructive effects and the safety rules children and others should follow.

*Hurricane Tracking Chart (Pacific) (NOAA/PA 77021) A single-sheet for following hurricane tracks across the Eastern Pacific Ocean and safety tips to follow during hurricane watches and warnings.

Some Devastating North Atlantic Hurricanes of the 20th Century (NOAA/PA 77019) A 14-page booklet on casualties, damage area and highest winds.

*Getting Through (NOAA/PA 77026) A two-color, four-panel folder containing a hurricane safety message for administrators of hospitals and other institutions.

Survival in a Hurricane (NOAA/PA 70027) A two-color, four panel wallet card describing safety rules for hurricane survival.

The Homeport Story (NOAA/PA 70028) A 24-page booklet describing actions that should be taken by a coastal city to get ready for hurricanes.

Hurricanes, Florida and You (NOAA/PA 75003) A three-color, 16-panel folder tailored to Florida residents and communities describing the hurricane as it affects Florida, providing information on storms that have damaged the state, and giving safety rules of particular interest to coastal Floridians.

When a Hurricane Threatens (NOAA/PA 76009) A 16-page, two-color booklet describing the hurricane's most dangerous forces -- storm surge, wind and flooding with an action checklist for each.

*Hurricane Tracking Chart (Atlantic) (NOAA/PA 77020) A single-sheet hurricane tracking chart with safety tips to follow during hurricane watches and warnings.

Disaster Preparedness (NOAA/PA 76021) A list of publications and films available from the National Weather Service.

10. The following films are available without charge (except postage) from:

Motion Picture Service
Department of Commerce - NOAA
12231 Wilkins Avenue
Rockville, Maryland 20852 phone (305) 443-8411

Flood, 15 min/color
Tornado, 15 min/color
Hurricane Decision 14 min/color
Gate to World Weather 28 min/color
The Global Weather Experiment - a whole earth view 14 min/color
descriptions of these films and others in
NOAA Motion Picture Films publication no. NOAA/PA-75023 also available
free from above address

Hurricane, 27 min/color
is available from: Film Librarian
Public Relations & Advertising Dept.
Aetna Life and Casaulty
151 Farmington Ave,
Hartford, Connecticut 06115
(203) 273-0123

TOPIC FIVE
SEA INTERACTS WITH THE LAND

TEXAS COASTAL CLIMATIC ZONES

Read--

The Gulf of Mexico interacts with the Texas Coast.

Look at--

Drawing of Terrain and Climatic Interactions of the Gulf.

Label--

Climatic Regions on the diagram.

Write--

Two paragraphs. One paragraph should describe the plants and animals one might find in Region A. The other would describe the plants and animals found in Region D.

Use--

A Texas Almanac to look up a county in each region to determine climate and products of that region.

Answer--

The questions on the climatic interactions of the land the Gulf. Use the Texas Almanac as a reference.

Read--

El Niño and discuss.

Discuss--

The importance of understanding the interaction between the atmosphere and the oceans.

Optional

Look at--

The weather forecasts to determine the interaction of the Gulf of Mexico with the land and the effects of this interaction on the weather.

THE GULF OF MEXICO INTERACTS WITH THE TEXAS COAST

I asked my friend, Sonny Day, at the Weather Bureau to tell us a little about the Gulf of Mexico and the weather along the coast. Here is his letter

Dear Captain Seaborne,

As you know the oceans affect our weather. They affect not only the weather of the coastal states but much of the United States as well. The overall climate of the coastal area is subtropical with long, warm to hot summers and short, mild winters.

The Gulf of Mexico affects the weather of a large portion of not only the coastal states but also the inland states. The moist air from the Gulf can move inland in the winter and its moisture can cause record snowfalls in the Mid-west (Kansas to Minnesota). In the spring the warm moist air of the Gulf can move northward colliding with a cold air mass moving south. Where they collide, there may be thunderstorms with strong winds and even tornados. An area where this often happens is the tornado alley of Texas(Wichita Falls area)and Oklahoma.

The characteristics of an air mass depend on where the air mass originates. If it originates over water, it will be moist. If it originates over a cold ocean it will be a cold, moist air mass. It is a warm, moist air mass if it originates over a warm ocean area. Also the moisture and varying temperature of the land depend largely upon the positions of the currents in the oceans. In studying weather or climate, one must also look at the role of the oceans. We can see this interaction by looking at the climate of the Texas Coast.

As we look at the Terrain and Climate Map we find that the interaction of the climate (weather of an area over a period of time) and the terrain along the Texas coast create four distinctly different regions. From Sabine River (Port Arthur) to Galveston we find a humid climate. Label this Region A. Then extending from Galveston to Port Lavaca (label this Region B) we find the wet subhumid climate where the moisture supply and loss are in balance. This is not true in the next zone, from Port Lavaca to Corpus Christi (label this Region C) which is a dry, subhumid belt. The transition between the dry subhumid region to that of semiarid (label this Region D), or almost desert, of the coast from Corpus Christi to Port Isabel, is gradual.

In the vicinity of Matagorda Bay there is an important climatic boundary. South of Matagorda Bay the potential evaporation rate is greater than the annual rainfall so south of this area, fresh water is in short supply. North of this area, the average annual rainfall is greater than the potential evaporation. This climatic factor is seen in the terrain along the coast. Is there a difference in the upper coast as compared to the lower coast? The surface climate has a direct effect on the marine environment. Roughly from Matagorda north, organisms are very similar to those off the coast of the temperate Atlantic (Carolinas and Virginia). However, from the Matagorda area south, tropical and subtropic organisms, like those of the Carribbean, occur. Yes, the size of the bays and river basins are smaller in the semiarid region compared to those in the humid region. Why? The amount of rainfall is less and the rivers carry less water so the bays are smaller. The bays and estuaries will also be saltier in the summer due to greater evaporation. Another feature is that as we move toward the lower coast, we find large areas of wind-blown sand due to the decrease in vegetation caused by the decrease in rainfall.

Another important climatic factor along the Gulf coast is the occurrence of extraordinary climatic events, such as hurricanes, tornadoes and heavy rainfall. The tornadoes and heavy rainfall may or may not be associated with hurricanes or tropical storms. Hurricanes strike the Texas coast on the average of once every 2.6 years.

During a hurricane, conditions along the coast are drastically changed and rather violent conditions may exist for a few hours to a few days. These conditions are: (1) a barometric low that causes a rise in the water level along the Gulf, (2) strong wind, (3) rising tide, (4) large waves (waves may grow 40 or 50 feet when a storm covers a large area), (5) heavy rains, (6)occasional tornadoes. When the storm strikes the coast, it (1) erodes beaches and dunes, (2) moves sediment, (3) floods lowlands.

The weather can and does interact with the land. Sometimes this interaction is violent and sudden, causing drastic changes in the coastal environment.

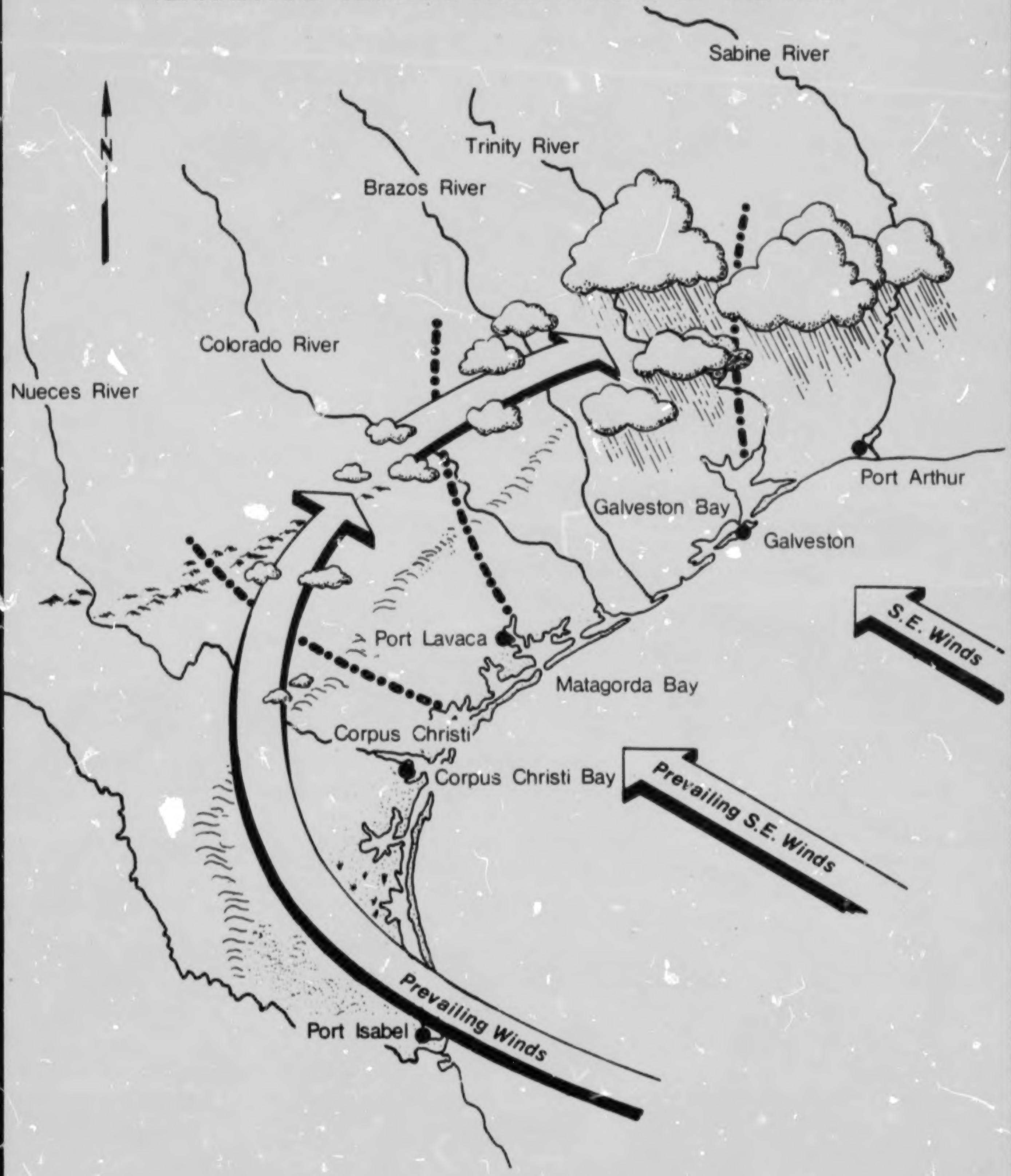
Sincerely,

Sonny Day

Sonny Day
U.S. Weather Bureau

P.S. I have enclosed an article "El Niño" which is an example of ocean and atmosphere interaction.

TERRAIN AND CLIMATIC INTERACTIONS OF THE GULF


Sabine River
Trinity River
Brazos River
N
Colorado River
Nueces River
Port Arthur
Galveston Bay
Galveston
S.E. Winds
Port Lavaca
Matagorda Bay
Corpus Christi
Corpus Christi Bay
Prevailing S.E. Winds
Port Isabel
Prevailing Winds

Questions:

1. Why would we find more windblown sand on the lower coast?

2. What effect do you think climate has on the salinity of the bays in Region A in comparison to D?

   Would they have a different salinity?

   Which would have the greater salinity?

   Would this affect the plants and animals?

3. How would the climate affect the agriculture of the region?

   In which regions would rice and timber be important?

   In which region would cotton, fruits and vegetables be important?

   Which regions would have to use irrigation?

   Would you expect to find the same cattle in each region?

   Would one kind of cattle be better for Region A versus Region D?

4. Do you think the climate would affect the kinds of jobs available? Explain.

EL NIÑO

Each year at the equator off the coast of Ecuador, a current brings in water that is 6 to 7°C. warmer than the surrounding water and much lower in salinity. This event is known as El Niño which means "The Child" or more specifically the Christ Child - symbol of the Christmas season. Occasionally, the current is stronger so it flows further south, displacing the cold Peru current. This causes widespread destruction of plankton and fish.

This has enormous ecological and economic effects. In Peru, the fish harvest is drastically lowered. The seabirds who depend on the fish die by the millions. This severely limits the annual guano (wastes from the birds) take. The guano is used for fertilizer in agriculture, and without it, the agricultural products decrease. This means less food for man and animals.

The dead fish and birds rotting on the beach also form hydrogen sulfide clouds. These clouds, combined with sea fog, will blacken the paint on ships, cars and houses. In severe El Niño years, heavy rains cause flooding and widespread crop damage. This adds to the catastrophe and problems along the coast.

The causes of El Niño are not fully understood. The El Niño is apparently correlated to cold winters in the United States and Europe, weakening of the Indian monsoon, heavy rains and unusual hurricane activity in the Pacific. The El Niño events do not occur in a regular, predictable cycle. However, when they do occur they are believed to cause poor food conditions in several areas of the globe.

El Niño affects the coastal updwelling, the upward motion in which nutrient-rich cold water of the depths is brought into the surface layer. These nutrient rich waters feed the plankton which are a source of food to the anchovy fish. During an El Niño year all the water is warm and low in nutrients and the anchovy population is decreased drastically. El Niño is only one event in a complex web of climatic disturbances. Large oceanic events accur almost every year in some region to affect the weather climate which, in turn, affects the ecology and economy.

In general, the interaction between the atmosphere and the ocean is poorly understood. Meteorologists believe that the oceans and the atmosphere above them possess the information needed for improved long-range weather prediction. The heat balance of the oceans is the most unknown element in the earth's heat balance. It cannot be ignored in any study of the climate. Studies in the last 10 years have determined that year-to-year changes in the location and strength of the major atmospheric centers of action over the ocean are related to large-scale changes in the temperature in the ocean. Meteorologists have been able to relate this to changes in climate that take place over the continents. The key to prediction of variations in the climate may be found in studying the oceans.

TOPIC FIVE
SEA INTERACTS WITH THE LAND

TROPICAL STORMS AND HURRICANES

Read--

Hurricane!
Spectacular Agent of Change

Look at--

Hazardous Sea Warnings.

Use--

The hurricane tracking map.

Plot--

The partial paths of the following hurricanes on the tracking map.

Hurricane	#1	#2	#3
Day 1--midnight	22°N 88°W	24°N 74°W	26°N 72°W
noon	24°N 89°W	25°N 76°W	28°N 75°W
Day 2--midnight	26°N 89°W	26°N 78°W	32°N 76°W
noon	28°N 90°W	28°N 79°W	36°N 74°W

Plot--

The path of a tropical storm or hurricane if there is one occurring at the time of this activity.

Read--

Hurricane flooding.

Look at--

The hurricane flooding--Houston-Galveston area map.

Complete--

The hurricane storm surge activities, "How Would You Prepare for a Hurricane?" Hurricane Safety Checklists.

Answer--

The questions.

Activities to be completed if you live in the coastal zone.

Discuss the Hurricane Safety Checklists with your family.

Use the Hurricane Safety Checklists to conduct a survey to determine the hurricane awareness of your area.

Check with the local civil defense and other offices to determine the hurricane disaster and evacuation plans for your community. Report on this to your classmates.

Interview individuals who have experienced a hurricane to get a firsthand report of it.

HURRICANE !

Dear Capt. Seaborne,

I have written some information on hurricanes for you to share with others.

A hurricane hits the Texas coast an average of once every 2.6 years and the pattern is that a major one occurs every 10 years. They bring rain, wind and exaggerated tidal surge. The damage is calculated in dollars by various agencies within the limits of their interest. However, the social upheaval caused by large scale destruction is more difficult to estimate and may only be estimated by one's imagination.

The increased population, severe subsidence in some areas, and "the odds" that the Texas coast is past due for a major hurricane have increased the need for hurricane awareness and preparation. It is possible that as much as a third or more of the coastal population has never experienced a hurricane.

Each hurricane is unique and different. Let's look at three recent hurricanes which hit the Texas coast and see the different types of damage:

Carla (1961) with winds over 160 mph, did most damage by salt-water flooding. In places, Carla's surge reached 21 feet above sea level and spread more than 10 miles inland.

The damage from Beulah (1967) was mostly from freshwater flooding following extremely heavy rainfall (27-30 inches). Beulah also had sustained winds over 120 mph and spawned more than 100 tornadoes, some as far inland as Austin.

Celia (1970) blew things down and apart. The winds were not much different from Beulah's but the gusts were very strong (recorder broke at 162 mph). These left trails of destruction across Corpus Christi.

Tropical cyclones form only during certain seasons of the year. Since 1871, which is as far back as our records extend, no tropical cyclone has hit the Texas coast before June or after October. This does not mean that they cannot form or strike Texas during other months, because new weather records are established almost every day. Tropical cyclones have formed as early as February and as late as December. For Texas the season has been from June through October.

The hurricane is one form of a tropical cyclone -- an immense, cyclonically (counterclockwise) swirling storm system covering thousands, sometimes hundreds of thousands, square miles. The tropical cyclones form and grow over warm water. The storms which approach the Texas coast form over the Gulf of Mexico, the Caribbean Sea, or the tropical areas of the North Atlantic Ocean. These areas are under the influence of the trade winds. Occasionally a low pressure area forms in the broad flow of the trade winds. A few of these lows develop into tropical cyclones.

When a low get stronger, the winds blow counterclockwise around it, an extensive cloud layer forms, and rain showers develop. If the weather conditions are favorable, a tropical cyclone may develop through the stages of tropical depression, tropical storm, hurricane, and even extreme hurricane.

Each hurricane is different! The description that follows is general and might not apply in all aspects to a specific hurricane. The eye of the hurricane is a feature which makes it unique from the cyclonic storms of the more northern latitudes. The eye is a somewhat circular area of comparatively light winds. It is usually rain-free and may vary from four to more than 40 miles in diameter. Diameters of 12 to 20 miles are common.

Hurricane winds are not symmetrical about the eye. When facing the direction in which the hurricane is moving, the strongest winds will usually be to the right of the eye. These winds may approach a speed of 200 m.p.h. The radius of hurricane force winds may be 50 miles, but it varies from 10 miles in small hurricanes to a hundred miles in larger storms. The strength of the wind decreases in relation to the distance from the eye. At 200 miles from the eye the winds may be gale force (38-54 m.p.h.) and gusty.

Rainfall forms in cumulonimbus clouds. The rainfall is showery and quite variable. As the clouds move past, rain starts and stops. Rain clouds spin around the storm like a large pinwheel while the center of the pinwheel is also moving. Rain is not evenly distributed about the eye. Most of the rain falls in the area of maximum winds. Rain squalls may extend out from the eye for 20 to 200 miles.

Low scud clouds accompany areas of rain. Cirrus clouds cover the cyclone and extend outward from it. Prior to the use of radar and aircraft reconnaissance, cirrus clouds were the first sign that a storm was approaching.

Hurricanes cause destruction in several ways:

strong winds may destroy some structures.
storm surge can level structures and float houses and boats from their foundations and moorings.
Heavy rains may cause flooding.
Tornadoes are often associated with hurricanes.
Residual problems, such as displacement of snakes from their usual habitats, disruption of communications and destruction of utilities, may arise after the passage of a hurricane. Public health measures must be taken to prevent illness and epidemics.

SPECTACULAR AGENT OF CHANGE

A few hours before there had been a thriving seaport--with its costly homes and beautiful churches. Warehouses filled with varied products of commerce and splendid shops on business streets now lay in ruins. Pavements and gardens were a mess. Every house was carried away or left in ruins. The cause--a hurricane, the greatest storm on earth. The death of Indianola--the mother of western Texas--was due to the visitation of two "once-in-a-century" hurricanes in eleven years (1875 and 1886). Before the storm of 1875, Indianola was second only to Galveston in the state as a port. It had a vast influence on the development of western Texas and in the settlement, protection and prosperity of Texas. Tens of thousands of immigrants to Texas entered here. Its wharves moved the necessities and luxuries for the people of western Texas. It was the port for trade with Mexico and the eastern terminal of the shortest overland route to California. It was the Government Depot for forts in western Texas and New Mexico. Its threat caused Houston businessmen to begin the development of the port of Houston.

The storm surge of the 1875 hurricane carried away three-fourths of the town and killed 176 people. Eleven years later the storm surge of the 1886 hurricane carried away or left uninhabitable every house in town. Indianola was never rebuilt and today the area is a state park. So widespread and devastating were the effects of the two hurricanes on Matagorda Bay that the entire region sank into a paralyzed economic state. It took more than half a century for it to recover. This agent of change not only causes natural changes but economic, social and historical changes as well.

The hurricane is the most spectacular agent of change in the Gulf coast. It can cause short-term changes or permanent changes in a few hours. It can totally destroy and move man-made structures. The hurricanes also change the land itself.

No two hurricanes are alike. Characteristics such as rainfall distribution, tornado occurance, storm surge and wind intensities are extremely variable. Therefore, changes caused by each will differ greatly. The surge (high level of the sea) of the Great Galveston Hurricane of 1900 destroyed more than 3,600 homes and killed an estimated 6,000 to 8,000 people (the worst weather related disaster in U.S. history). Hurricane Celia (1970) destroyed an estimated $500 million worth of property and became the costliest to strike the Texas coast. Nearly all damage was a result of wind, not flooding or storm surge. Beulah (1967) was another unique hurricane; she drenched the state with its greatest rainfall and caused the most tornadoes (more than 100). Many areas received more rain from Beulah than they would normally receive in a year. The rains set off major flooding of every river and stream south of San Antonio.

A hurricane starts a series of processes that cause change. During the hurricane's approach, landfall and inland movement, conditions along the coast are drastically changed. Rather violent conditions may exist for a few hours to a few days.

The approach of the hurricane is marked by rising tides and increased wind. This brings large amounts of salt water into the bays and estuaries. When the storm reaches the coast, it erodes beaches and dunes. It carries sediments and salt water from the continental shelf toward the barrier islands and peninsulas. In some areas it will break over the barrier islands. The sediment which it erodes from the beaches and dunes is carried through the storm channels and spread over the mud flats and marshes and into the bays.

When the hurricane center reaches land, the currents and waves change direction. Water and sediments are now washed out from the bays into the Gulf. The highest winds are experienced as the storm moves onto land. The heavy rains from the hurricanes may cause flooding along the streams and flood the bays with fresh water.

After the storm passes from the coastal area, the currents build sand bars across the mouths of the hurricane channels. The waves then attempt to restore the beach to normal.

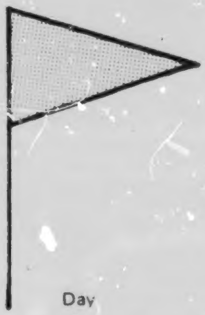
The most spectacular effect produced by hurricanes, other than the destruction of man-made structures, is the erosion by the breaking waves. The storm surge, or the abnormal rise in the level of the sea, causes the greatest concentration of death and destruction. The waves may be as high as 40 or 50 feet when a storm covers a large area. The dunes on the barrier islands may give some protection from storm surge and waves. Often the dunes are not high enough, however, so the waves of large hurricanes will wash over the top of them. Large hurricanes wash over miles of land. They can also severely erode and break the barrier islands. In some places, there has been as much as 800 feet of shoreline eroded.

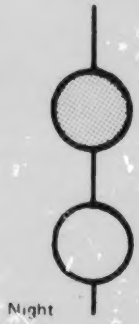
If a 50—or 100—year hurricane centered on Galveston Bay. it could flood more than 1,000 square miles if the hurricane tidal surge reached 25 feet above mean sea level.

Yes, hurricanes are spectacular and violent agents of natural change but they also cause economic, social and historical changes.

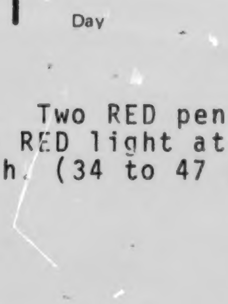
HAZARDOUS SEA WARNINGS

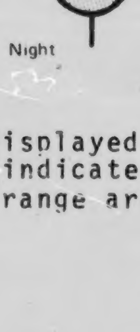
Colored pennants and lights are displayed in some ports and areas of the Texas coast to warn of hazardous sea conditions. Modern technology, however, has reduced the number of flag stations needed along the coast. Now emphasis is placed on continuous marine broadcasts transmitted at 162.55 MHz.



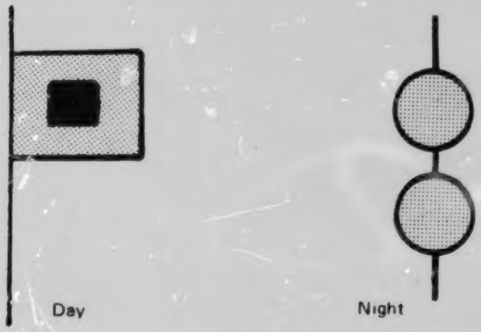


Small Craft Advisory. One RED pennant displayed by day and a RED light over a WHITE light at night to indicate the winds and seas, or sea conditions alone, are considered dangerous to small craft operations. Winds may range as high as 38 m.p.h. (33 knots.)

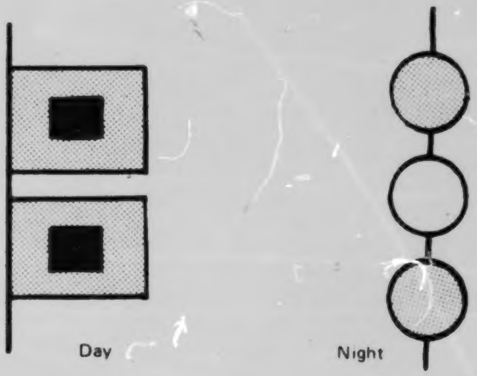




Gale Warning. Two RED pennants displayed by day and a WHITE light above a RED light at night indicate winds within the 39 to 54 m.p.h. (34 to 47 knots) range are forecast for the area.

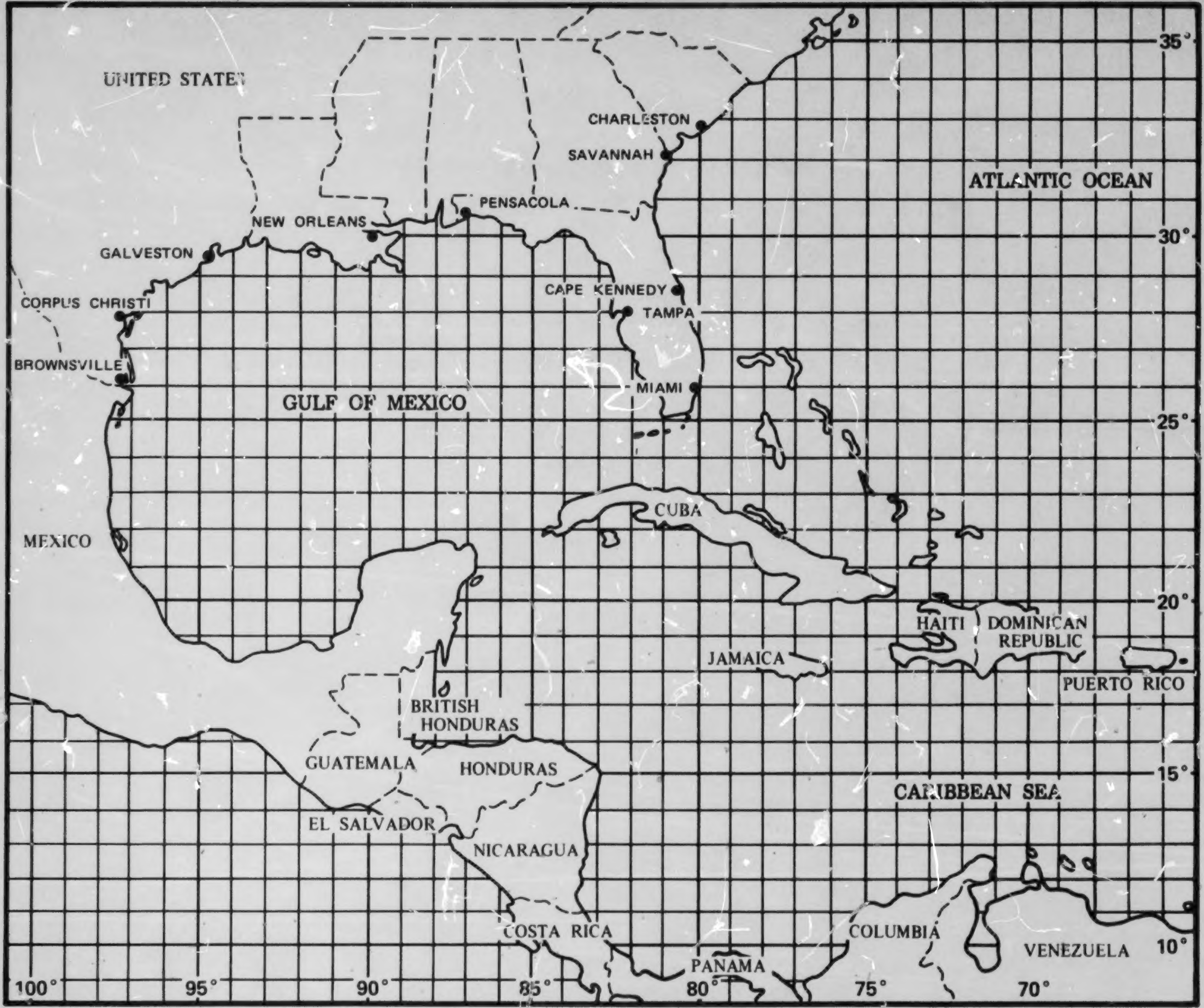


Storm Warning. A single square RED flag with a BLACK center displayed during daytime and two RED lights at night indicate winds within the 55 to 73 m.p.h. (48 to 63 knots) range are forecast for the area.



Hurricane Warning. Two square RED flags with BLACK center displayed during the day and a WHITE light between two RED lights at night indicate that winds 74 m.p.h. (64 knots) and above are forecast for that area.

(From Hurricanes of the Texas Coast, Texas A&M University Sea Grant Program, TAMU-SG-75-504.


UNITED STATES
CHARLESTON
SAVANNAH
ATLANTIC OCEAN
PENSACOLA
NEW ORLEANS
GALVESTON
CAPE KENNEDY
TAMPA
CORPUS CHRISTI
BROWNSVILLE
MIAMI
GULF OF MEXICO
CUBA
MEXICO
HAITI
DOMINICAN REPUBLIC
JAMAICA
PUERTO RICO
BRITISH HONDURAS
GUATEMALA
HONDURAS
CARIBBEAN SEA
EL SALVADOR
NICARAGUA
COSTA RICA
COLUMBIA
VENEZUELA
PANAMA
35°
30°
25°
20°
15°
10°
100°
95°
90°
85°
80°
75°
70°

HURRICANE FLOODING

One of the ways in which hurricanes cause destruction is by flooding which is due to heavy rains and the storm surge. Since Carla (1961) hit the Houston-Galveston Bay area things have changed greatly around the Galveston Bay area. There has been extensive land development such as that by NASA and the petrochemical industry. Hundreds of acres in Harris and Galveston counties have been developed and large amounts of groundwater have been removed. This has resulted in the land sinking as much as 5-7 feet in places and has drastically increased the flooding danger.

In most hurricanes, "storm surge" causes most loss of life and property damage. Storm surge is different than regular tides. Together, regular tides and the storm form the "hurricane tide."

Storm surge development takes place over deep water, where the drop in barometric pressure in the storm center causes the sea to bulge. A second action develops as hurricane winds sweep across the sea surface. This causes a swirling movement of the surface water which gradually goes down about 50 fathoms (300 feet). The maximum swirl moves to the right of the hurricane's eye (track), where wind speeds are highest. There is no change in sea level due to this swirling motion as long as the water remains deeper than 50 fathoms.

As the hurricane approaches land, the swirling water mass scrapes bottom, tries to spread in all directions, and begins to pile up. Peak surge heights are seen at the shoreline about the time the hurricane center reaches land.

The maximum water swirl occurs 10-20 miles to the right of the storm track, near the point of maximum wind speeds. Thus, the greatest danger from both winds and surge usually is about 15 miles right of the storm's eye.

The surge may lift the ocean 15 feet or more at the coastline. Carla produced a 21-foot surge at Matagorda Bay. Camille, which hit Mississippi in 1969, caused a 25-foot surge, the highest ever recorded in the Western Hemisphere. Defenses against storm surge are few. Sea walls and strongly constructed buildings offer some protection, but they are not invincible. The only sure way to avoid destructive surges is to not build in low-lying coastal areas. Unfortunately, most of the Texas coast is below the 20-foot elevation.

The National Weather Service, in a recent report, points out that if Carla returned, she would directly affect at least 50,000 more people and cover Interstate 45 in several places not affected in 1961. This, in effect would cut off escape routes that were useable in 1961. The situation will become worse. Even if groundwater removal stopped today, subsidence would continue several years. The land boom on Galveston Bay shows no sign of slowing. Most of the people who move in are unaware of the "big one" that is certain to come some day.

On the hurricane flooding-Galveston area map do the following activities:

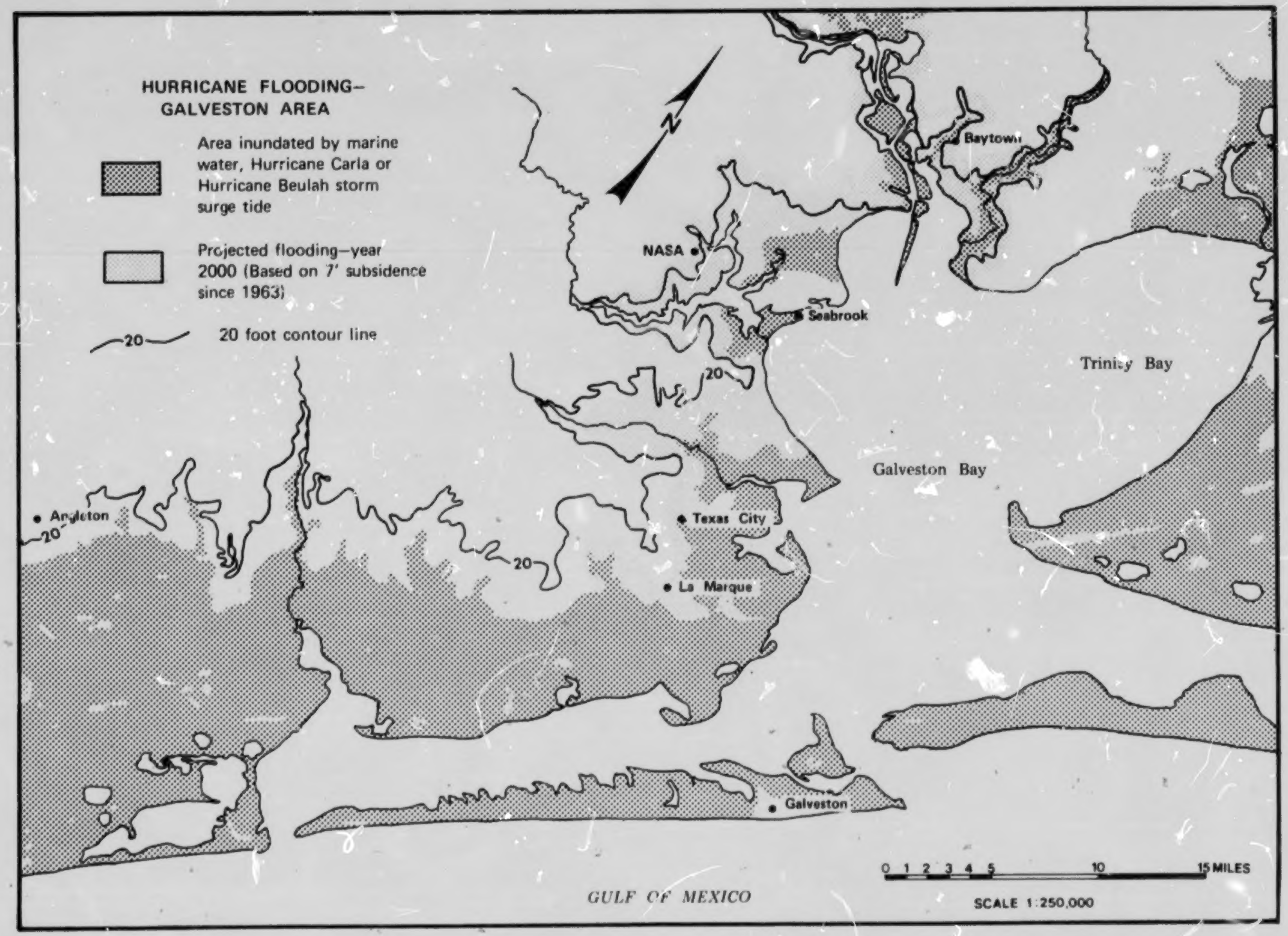
A. Locate the 20 foot contour line and color it red.
B. Locate the area flooded by marine water by Hurricane Carla or Beulah storm surge tides and color it medium blue.
C. Locate the area which would have been flooded by a Carla-type hurricane in 1973 and color it light blue.
D. Locate the area which will be flooded in the year 2000 if the subsidence continues at the same rate and color it yellow.

Use the hurricane flooding-Galveston area map and a Texas Highway map and:

A. List all the towns of more than 5,000 people which would be flooded by a hurricane with a 20-foot storm surge entering Galveston Bay.
B. Where would the greatest danger of storm surge occur if the eye of a hurricane hit Galveston?
C. Where would the greatest danger of storm surge occur if the eye of a hurricane hit land approximately 8 miles to the right or east of San Luis Pass?

Optional:

If you live in the coastal area, use the hurricane flooding map of your area to determine flooding due to storm surges.


HURRICANE FLOODING–
GALVESTON AREA
Area inundated by marine water, Hurricane Carla or Hurricane Beulah storm surge tide
Projected flooding–year 2000 (Based on 7' subsidence since 1963)
20 foot contour line
20
N
Baytown
NASA
Seabrook
Trinity Bay
Galveston Bay
Angleton
Texas City
La Marque
Galveston
GULF OF MEXICO
0 1 2 3 4 5 10 15 MILES
SCALE 1:250,000

HURRICANE STORM SURGE

Preparing for a major disaster on the Texas coast requires planning and action by entire communities. It must include careful preparation by officials of how, when and where to move people under constantly changing conditions. Some form of coastal land use management to reduce exposure of lives and property is needed. There also needs to be an awareness program aimed at educating the public to cope with hurricanes.

If you live in the coastal zone, complete the hurricane-safety checklists individually before discussing the questions with your classmates. If you do not live in the coastal zone, discuss the questions on the checklists with your classmates.

Answer the questions.

1. Why should you plan to evacuate the area if your home is less than 25 feet above sea level?

2. Why is it extremely important to stay inside during the storm and not go out during the lull when the eye is passing?

3. Why does everything need to be stored or tied down?

4. Why would it be best not to build in areas where storm surges can flood?

If you live in the coastal zone use a hurricane flood map of your area to determine the effect of a hurricane on your area. If you do not live on the coast select a town or city on the coast and use the hurricane flood map of the area to determine the effects of a hurricane on the area. Or use the Hurricane Flood Map-Galveston area to determine the flooding of a town or city located in the map area. Briefly describe the effects.

Use the Hurricane Flood Map-Galveston area or one of the coastal area you live in to plan the evacuation of a town or city that could be in the path of a hurricane. Describe the evacuation procedures you would follow.

Discuss the use of coastal land use management to reduce exposure of people and property to the destruction of hurricanes.

HOW WOULD YOU PREPARE FOR A HURRICANE ?

Here are three hurricane checklists for evaluating home safety, deciding whether or not to remain at home, and evacuating the area. Individuals are urged to use these checklists now, to review them periodically, and to share them with friends. Extra, removable copies are included in the back of this booklet.

It is best to designate one place, such as the inside of a closet door, as the emergency center of the house. A framework can be installed to hold a first-aid kit, snake-bite kit, flashlight, candles, waterproof match box, and booklets on first aid, civil defense, tornado safety and hurricane preparedness. A fire extinguisher is recommended. Emergency phone numbers should be listed on the door in large letters that can be read in poor light and without glasses.

A. CHECKLIST FOR EVALUATING HOME HURRICANE SAFETY

YES/NO

_____ 1. Is your home within 20 miles of the coast?

_____ 2. Is your home less than 25 feet above mean sea level?

_____ 3. Is your home in an area susceptible to flash floods or river system floods?

_____ 4. Do you live in a mobile home within 50 miles of the coast? If your answer is "yes," plan to evacuate your home and proceed to the evaluation checklist.

If you have answered "yes" to any questions above, complete Checklist A. Then proceed to the checklist applicable to your plans for weathering a hurricane--remaining at home or evacuating the area.

_____ 5. Is your insurance coverage suitable?

_____ 6. Have you stored your valuable papers, jewelry, keepsakes, etc. in a bank vault or secure place that will be safe from storms, fires or looters?

B. CHECKLIST FOR REMAINING AT HOME DURING A HURRICANE

YES/NO

_____ 1. Are you aware that mobile homes are more susceptible to damage by high winds than other types of housing? Your mobile home should be tied at all times. When a hurricane approaches leave for more substantial shelter.

_____ 2. If you own a boat, is it moored securely? Do not attempt to ride out a storm on your boat or to return to check its moorings after the storm has arrived. Small boats can be tied close to the house and filled with water to keep them from being blown away.

_____ 3. Do you have a full tank of gasoline in your car? Authorities may advise you to evacuate if conditions worsen and your home is no longer safe. If electric power is off, filling stations may not be able to operate pumps for several days.

_____ 4. Have you stored or secured outdoor objects that could be blown away or uprooted? Garbage cans, garden tools, awnings, TV antennas, signs, outdoor furniture and toys can become lethal projectiles in hurricane-force winds.

_____ 5. Are windows boarded or shutters in place? (Use good lumber and make sure it is fastened securely. Makeshift boarding or plywood may come apart when wet and do more damage than not having taken any precautions.)

_____ 6. Do you have strong bracing for outside doors?

_____ 7. Are flashlights and/or emergency lights working? Do you have extra batteries?

_____ 8. Do you have a sufficient supply of drinking water on hand? Since city water service may be interrupted, you should sterilize the bathtub, jugs, bottles, pots and pans and fill them with water. Water in the hot water tank may be used for drinking. A supply of water purification tablets is recommended.

_____ 9. Have you stocked non-perishable food that does not need refrigeration and can be eaten without cooking or with little preparation? Remember that electric power may be off and you may be without refrigerator or stove.

_____10. Do you have sufficient medication and prescription drugs?

_____11. Do you have a portable radio in working condition so that you can listen to local stations for storm watches and warnings and for instructions from the local EOC?

_____12. Do you have an axe and wrecking bar immediately available? If the house shifts or falls, these tools may be needed to open doors or to rescue trapped individuals.

_____13. Have you moved furniture away from exposed windows and doors? Tape windows to reduce the possibility of flying glass.

_____ 14. Do you know that it is extremely important to stay inside during the storm and not to go out during the lull while the eye is passing?

_____ 15. Do you know how to shut off the main gas valve and to pull the main power switch if the house starts to flood? Flooding will extinguish pilot lights and gas may leak. High water can cause shorting of electric lines which could start fires. It is unlikely that help will be available to control or extinguish fires.

_____ 16. Are you aware of the dangers (flying debris) of opening a door or window on the windward side of the house? Exit on the downwind side if possible.

_____ 17. Are you prepared to evacuate if required? Take only necessary clothing. (It is advisable to have a suitcase packed.) See Appendix VII, Part 5. Hurricanes of the Texas Coast, Texas A&M Sea Grant Program TAMU - SG-75-504.

_____ 18. If you have to evacuate at the last minute, do you know which evacuation route to use? Keep up-to-date on the best route by listening to the radio in your area.

a. Use route ____________ to ________________.

b. Use route ____________ to ________________.

c. Use route ____________ to ________________.

_____ 19. Do you have the location and telephone number of the nearest Red Cross shelter posted in your house? Information will be given over radio concerning available shelters. Remember that the list may not include the shelter closest to your home.

a. Address __________________________ Phone ____________

b. Address __________________________ Phone ____________

c. Address __________________________ Phone ____________

_____ 20. Do you know that downed electric power lines are extremely dangerous? Do not move or touch them.

C. CHECKLIST FOR EVACUATING THE AREA

If you decide to evacuate, try to leave during daylight hours well in advance of the storm. Heavy rains and high winds usually precede the storm by six hours.

YES/NO

_____ 1. Have you tied down your mobile home? See Appendix XII of Hurricanes on The Texas Coast, Texas A&M University Sea Grant Program, TAMU - SG-75-504 or the Civil Defense office publication TR-75 Protecting Mobile Homes from High Winds

_____ 2. Is a car with a full tank of gasoline ready if needed? Walk to shelter when possible to help alleviate traffic congestion.

_____ 3. If you own a boat is it moored securely? (Do not attempt to ride out a storm on your boat or to return to check its moorings after the storm arrives.) Small boats can be tied next to the house and filled with water to keep them from being blown away.

_____ 4. Have you stored or secured outdoor objects that might be blown away? Garbage cans, garden tools, awnings, TV antennas, signs, outdoor furniture, and toys can become lethal projectiles in hurricane-force winds.

_____ 5. Are windows boarded or shutters in place? Taping windows helps to reduce flying glass.

_____ 6. Do you have strong bracing for outside doors?

_____ 7. Have you moved furniture away from exposed windows and doors?

_____ 8. Do you have sufficient prescription drugs or medicines?

_____ 9. Have you taken only necessary clothing? See Appendix VII, Part 5 of Hurricanes of the Texas Coast, Texas A&M Sea Grant Program - TAMU-SG-75-504.

_____ 10. Have you shut off the main gas valve and pulled the main power switch before leaving?

_____ 11. Do you know that downed electric power lines are extremely dangerous? Do not move or touch them.

_____ 12. Are you familiar with the best evacuation route to use?

a. Use route ___________ to __________.

b. Use route ___________ to __________.

c. Use route ___________ to __________.

_____ 13. If you are marooned, do you know the location and telephone number of your nearest Civil Defense or Red Cross shelters?

a. Address ____________ Phone __________

b. Address ____________ Phone __________

c. Address ____________ Phone __________

1. Write a paragraph describing a coastal area before and after a hurricane .

2. What effect would the large movement of water into the bays and estuaries (with high tides) and then out again (with rainfall) have on the plants and animals of the bays and estuaries?

3. How does the possibility of hurricanes affect people living along the coast? structure of buildings? insurance? jobs?

4. Should man work to control hurricanes? How willing are you to contribute money to be used to learn more about hurricanes to control them?

5. Discuss why the ocean may be the key to our understanding of the weather and variations in the climate.

TOPIC SIX
THE MARINE ENVIRONMENT AND MARINE ORGANISMS

ACTIVITY ONE--Zones of the Marine Environment
ACTIVITY TWO--Basic Groups of Marine Organisms
ACTIVITY THREE--Intertidal Ecosystems
ACTIVITY FOUR-- Marine Organisms-Let's Get Acquainted

Materials for Classroom Use:

Zones of Marine Environment/reading and questions
Zones of Marine Environment/sketch
Nutrients and Salts/sketch
Dissolved Oxygen/sketch
Light Penetration/sketch (See Topic 4)
Marine Zones and Abiotic
Characteristics/chart
The Nekon/reading and sketch
The Plankton/reading and sketch
The Benthos/reading and sketch
Distribution of Marine Organisms/sketch
Questions on distribution of marine organisms
Aerial View of Coastal Habitats/sketch
Profile of Coastal Habitats/sketch
Marine Ecosystems of the Gulf of Mexico/reading
Rocks, Jetties and Groins/reading & sketch
Sandy Beaches/reading & sketch
Oyster Reef/reading & sketch
Salt Marshes/reading & sketch
Mud Flats/reading & sketch
The Water, Itself/reading & sketch

[Reference for sketches Jetties, Sandy Beach, Mud Flats and The Water are courtesy Reader's Digest Secrets of the Seas Marvels and Mysteries of Ocean and Islands)

Underwater Life/activity
Syntu About a Marine Organism/activity
Marine Life along the Coast of the United States
Let's Get Acquainted/activity
Name the Animal/activity
Specially Designed/reading
Design a Beak/activity
Marine Mobiles
Gyotaku: Preserve it with a Print/activity

Major Objectives for the Topic:

After completing the activities the student will be able to:

1.1 define abiotic and biotic factors;
1.1 cite examples of abiotic and biotic factors in a given ecosystem;

1.1 draw a cross section showing the zones of the marine environment;
1.1 compare and contrast the zones of the marine environment;
1.1 if given organisms, classify them as benthos, plankton and nekton;
1.1 distinguish between environment and ecosystem;
1.2 compare and contrast the characteristics of different marine ecosystems;
1.2 describe how abiotic and biotic factors influence the distribution of marine organisms;
1.2 cite an example of marine organisms being adapted to their environments in different ways;
1.2 if given a set of abiotic factors (light. temperature, pressure, chemicals, etc.), relate them to the existing ecological relationships;
1.2 if given two or more ecosystems, to identify common structural and functional characteristics;
1.3 explain the role of the phytoplankton in the ecosystem.

Teaching Suggestions:

The purpose of this lesson is to inform the student and help him recognize the zones of the marine organisms and ecosystems in the intertidal zone.

1. Have the students look at the sketches and complete the readings and activities on the zones of the marine environment and the groups of marine organisms.

2. You may use the readings as a reference for class lecture and discussion. However having the students use it as a reference and developing a skit or interview is much more effective. How effective it is will depend on your encouragement. You may have the students obtain additional information from the library.

3. For more information on writing a syntu about marine organisms see Topic One, Syntu about the Sea activity.

4. The Marine Life along the coast of the United States can also be an English exercise (some of your students probably will not have composed a business letter before.) You may want to limit the items requested to shells, algae or specific marine organisms. Have the students address the letters to science department or biology, ecology, or marine science classes at the various schools. The specimans, identified by type and location, can form a permanent learning center in your room which can be added to yearly. Make sure your students realize that they probably will not receive an answer to each letter.

5. The Let's Get Acquainted activity is designed to help students realize that the organisms have distinct features which can be almost human-like.

6. Have students read the paragraphs in the Name the Animal activity and see if they can identify the organism which is being described. The animals in order are: sea horse, starfish, octopus and sea gull. After this you may want to have the students read an article (see list at the end of this section) about a marine organism, write their own Name the Animal paragraph and see if their classmates can identify the organism.

7. After the students read and discuss Specially Designed, you may want to have them discuss how the marine organism is specially designed.

8. In the Design a Beak activity have the students sketch the beak design which they feel would be best for the purposes described. Share and discuss the beak design as a class. There is no right answer. You may want to have the students use bird books and look at the beaks in relation to how they are used. The beaks described are similar to the following: No. 1 - oystercatcher; No. 2 - long-billed curlew; No. 3 - cormorant; No. 4 - avocet; No. 5 - plover. Using this idea, you may want to design a body build, legs, etc., for an animal which does specific things. For example, the legs and feet of a swimmer and diver; legs and feet of a wader in the marsh, etc.

9. The Gyotaku is an excellent way to combine the study of the structures of fish and art and also compile a permanent record to study.

10. You may have the students make shell mobiles. As part of this activity have the students try to identify and label the shells which they use. Other materials (drawings, etc.) can be used to make mobiles of other marine organisms.

11. Eat Your Dissection--Instead of using preserved specimens in dissecting organisms, obtain fresh or frozen samples of clams, oysters, scallops, mussels, lobsters, shrimp, crabs, fish, etc. Have the students dissect these specimens, removing the edible parts first. Use a crock pot or other modern appliance to cook these edible parts in the classroom. One advantage of fresh or frozen samples is that the specimens are not disclored by preservatives. Another is that the students are not forced to handle preserved specimens. Best of all, they can learn what parts are edible, how to use them and how they taste. (See references in Topic 13 for recipes.) Your home economics department may be able to work with you or help you. If you live in the coastal area, your students may even provide the specimens.

12. Below is a list of some articles on marine organisms and environments. (These articles also can be used in Topic Seven.)

National Geographic Magazine Articles

Starfish Threaten Pacific Reefs, Vol. 137, No. 3 (March 1970) pp. 340-354.
Diving into the Blue Holes of the Bahamas, Vol. 138, No. 3 (Sept. 1970) pp. 347-363.
The California Gray Whale Comes Back, Vol. 139, No. 3 (March 1971) pp. 394-415.

Shy Monster, The Octopus, Vol. 140, No. 6 (Dec. 197[illegible]) pp. 776-800.
The American Lobster, Detectable Cannibal, Vol. 143, No. 4 (April 1973) pp. 462-487.
Australia's Great Barrier Reef, Vol. 143, No. 6 (June 1973) pp. 727-779.
Life Cycle of a Coral Captured in Color, Vol. 143, No. 6 (June 1973) pp. 780-794.
Firned of the Wind: The Common Ferm, Vol. 144, No. 2 (August 1973) pp. 234-247.
The Friendless Barnacles, Vol. 144, No. 5 (Nov. 1973) pp. 623-669.
The Heron that Fishes with Bait, Vol. 145, No. 1 (Jan. 1974) pp. 143-147.
Blue-water Plankton, Vol. 146, No. 4 (Oct. 1974) pp. 530-571.
Bad Days for the Borwn Pelican, Vol. 147, No. 1 (Jan. 1975) pp. 111-123.
Diving Amid "Sleeping" Sharks, Vol. 147, No. 4 (April 1975) pp. 570-584.
Strange March of the Spiny Lobster, Vol. 147, No. 6 (June 1975) pp. 819-831.
The Chambered Nautilus, Exquisite Living Fossil, Vol. 149, No. 1 (Jan. 1976) pp. 38-42.
Life or Death for the Harp Seal, Vol. 149, No. 1 (Jan. 1976) pp. 129-142.
Adrift on a Raft of Sargassum, Vol. 149, No. 2 (Feb. 1976) pp. 188-199.
At Home with Right Whales, Vol. 149, No. 3 (March 1976) pp. 322-339.
Whales-Imperiled Giants, Vol. 150, No. 6 (Dec. 1976) pp. 722-751.
Exploring the Lives of Whales, Vol. 150, No. 6 (Dec. 1976) pp. 752-766.
Sponges, Vol. 151, No. 3 (March 1977) pp. 392-408.
Oases of Life in the Cold Abyss, Vol. 152, No. 4 (Oct. 1977) pp. 441-454
A Bad Time to be a Crocodile, Vol. 153, No. 1 (Jan 1978) pp. 90-116.
Hawaii's Far-Flung Wildlife Paradise, Vol. 153, No. 5 (May 1978) pp. 670-691.
Dragons of the Deep, Vol. 153, No. 5 (June 1978) pp. 838-845.
Palau's Dazzling Corals, Vol. 154, No. 1 (July 1978) pp. 136-150.
Undersea Wonders of the Galapagos, Vol. 154, No. 3 (Sept. 1978) pp. 362-381.
Humpbacks: The Gentle Whales, Vol. 155, No. 1 (Jan. 1979) pp. 2-17.
Humpbacks: Their Mysterious Songs, Vol. 155, No. 1 (Jan. 1979) pp. 18-25.
Island, Prairie, Marsh and Shore, Vol. 155, No. 3, (March 1979) pp. 350-381.
The Trouble with Dolphins, Vol. 155, No. 4 (April 1979) pp. 506-541.
Killer Whale Attack! Vol. 155, No. 4 (April 1979) pp. 542-545.

Texas Parks and Wildlife Magazine Articles

Alligator Holes, Vol. 31, No. 5 (May 1973) pp. 20-23.
Black Skimmer, Vol. 31, No. 6 (June 1973) pp. 6-9.
Many Animals in One, Vol. 31, No. 8 (Aug. 1973) pp. 20-22.
Welcome Aboard (Trip to winter home of Whooping Crane) Vol. 31, No. 12 Dec. 1973) pp. 2-5.
Whales, Porpoises and Dolphins of Texas, Vol. 32, No. 1 (Jan. 1974) pp. 12-15.
The Toothed Whale, Vol. 32, No. 2 (Feb. 1974) pp. 12-14.
Dolphins of Texas, Vol. 32, No. 3 (March 1974) pp. 18-22.
Waders by Wary (Stingray), Vol. 32, No. 6 (June 1974) pp. 6-8.
Monitoring the Peregrine, Vol. 32, No. 9 (Sept. 1974) pp. 2-5.
Terns, Vol. 33, No. 1 (Jan. 1974) pp. 2-5.
Clean-up Squadron (Sea Gulls) Vol. 33, No. 2 (Feb. 1975) pp. 2-5.
Flatfish, Vol. 33, No. 6 (June 1975) pp. 26-29.
From the Common to the Bizarre, Vol. 34, No. 2 (Feb. 1976) pp. 16-21.
The Great Blue, Vol. 34, No. 3 (March 1976) pp. 6-9.
Clown of the Shorebirds, Vol. 34, No. 5 (May 1976) pp. 16-18.
Crabs, Vol. 34, No. 8 (August 1976) pp. 2-5.

Young Naturalist: Coquina, Vol. 34, No. 8 (August 1976) pp. 28-31.
Fish Hawk, Vol. 34, No. 12 (Dec. 1976)pp. 24-26.
Long Legged Wading Birds, Vol. 35, No. 2 (Feb. 1977) pp. 12-15.
Black Drum, Vol. 35, No. 2 (Feb. 1977) pp. 19-21.
Pelican Comeback, Vol. 35, No. 3 (March 1977) pp. 12-15.
Young Naturalist: Hermit Crab, Vol. 35, No. 11 (Nov. 1977) pp. 30-31
Man-of-War, Vol. 25, No. 6 pp. 28-31.

How to: Set up a Salt Water Aquarium, Vol. 34, No. 2 (Feb. 1976) pp. 29-31.
How to: Build an All Glass Aquarium, Vol. 33, No. 6 (June 1976) pp. 20-21.

Andrews, Jean, Sea Shells of the Texas Coast. Austin: University of Texas Press, 1971.

Fotheringham, Nick, and Brunemeister, Susan Lee. Common Marine Invertebrates of the Northwestern Gulf Coast. Houston, Texas: Gulf Publishing Company, 1975.

Hoese, H. Dickson, and Moore, Richard H. Fishes of the Gulf of Mexico, Texas, Louisiana, and Adjacent Waters. College Station: Texas A&M University Press, 1977 $7.95 paperback. 330 color photographs.

Peterson, Roger Tory. A Field Guide to the Birds of Texas. Boston: Houghton Mifflin Company, 1960.

The Ocean World of Jacques Cousteau. 20 Volumes. Publishers of the Ocean World of Jacques Cousteau. Danbury Press. Sherman Turnpike, Danbury, Connecticut 06916.

Reader's Digest - Secrets of the Seas-Marvels and Mysteries of Oceans and Islands. The Reader's Digest Association, Pleasantville, New York, 1972.

AQUATIC SCIENCE: MARINE FISHERIES BIOLOGY TAMU-SG-78-402
no charge for single copies
2-10 copies, 50¢ each
10 or more copies, 25¢ each

This book includes sections dealing with bays, shores and estuaries, fish and shellfish identification and life history and management. Contains 18 pages, 21 illustrations

Order from:
Sea Grant College Program Publications
Texas A&M University
College Station, TX 77843

TOPIC SIX
THE MARINE ENVIRONMENT AND MARINE ORGANISMS

ZONES OF THE MARINE ENVIRONMENT

Read--

Zones of the Marine Environment.

Look at--

Diagram of "Zones of the Marine Environment."

Answer--

Questions.

Look at--

Drawings of the abiotic factors in the three zones of marine environment.

Diagram of Nutrients and Salts.

Diagram of Dissolved Oxygen Concentrations.

Complete--

The Marine Zones and Abiotic Characteristics chart.

Answer and discuss--

Questions.

ZONES OF THE MARINE ENVIRONMENT

The earth can be divided into two types of environments: (1) terrestrial or land environments (2) aquatic environments--fresh and salt water. Look at the sketch "Zones of Marine Environment" profile. The salt or marine environment can be divided into three zones: (1) open ocean -- which contains all the ocean waters above the continental shelf and beyond the continental shelf; (2) sea floor -- which consists of the floor of the continental shelf and the deep ocean basin and (3) the intertidal or litoral zone -- which consists of the zone affected by the tides. Later we shall divide this zone into more areas and look at each. The abiotic factors (the non-living physical and chemical characteristics) of each zone vary.

Questions

1. Can you name some abiotic or non-living factors that influence marine environment?

2. List some ways the zones are alike.

3. List some ways the zones differ.

4. Can you give some examples of how the abiotic (non-living) factors of a zone determine the organisms which could live in that zone.

5. What kinds of organisms would you expect to find in each of the zones? Give your reasons.

ZONES OF MARINE ENVIRONMENT

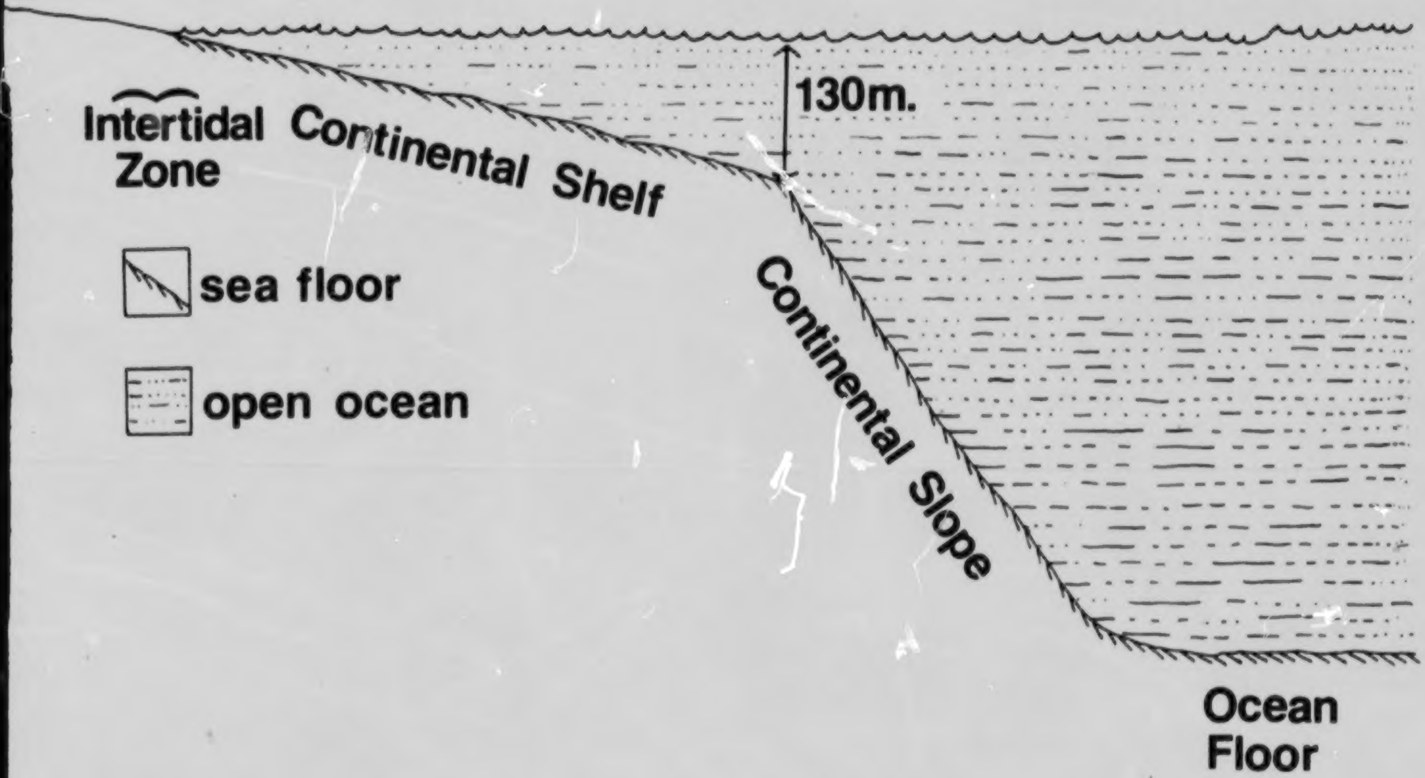

130m.
Intertidal Zone
Continental Shelf
sea floor
open ocean
Continental Slope
Ocean Floor

DIAGRAM OF

NUTRIENTS & SALTS

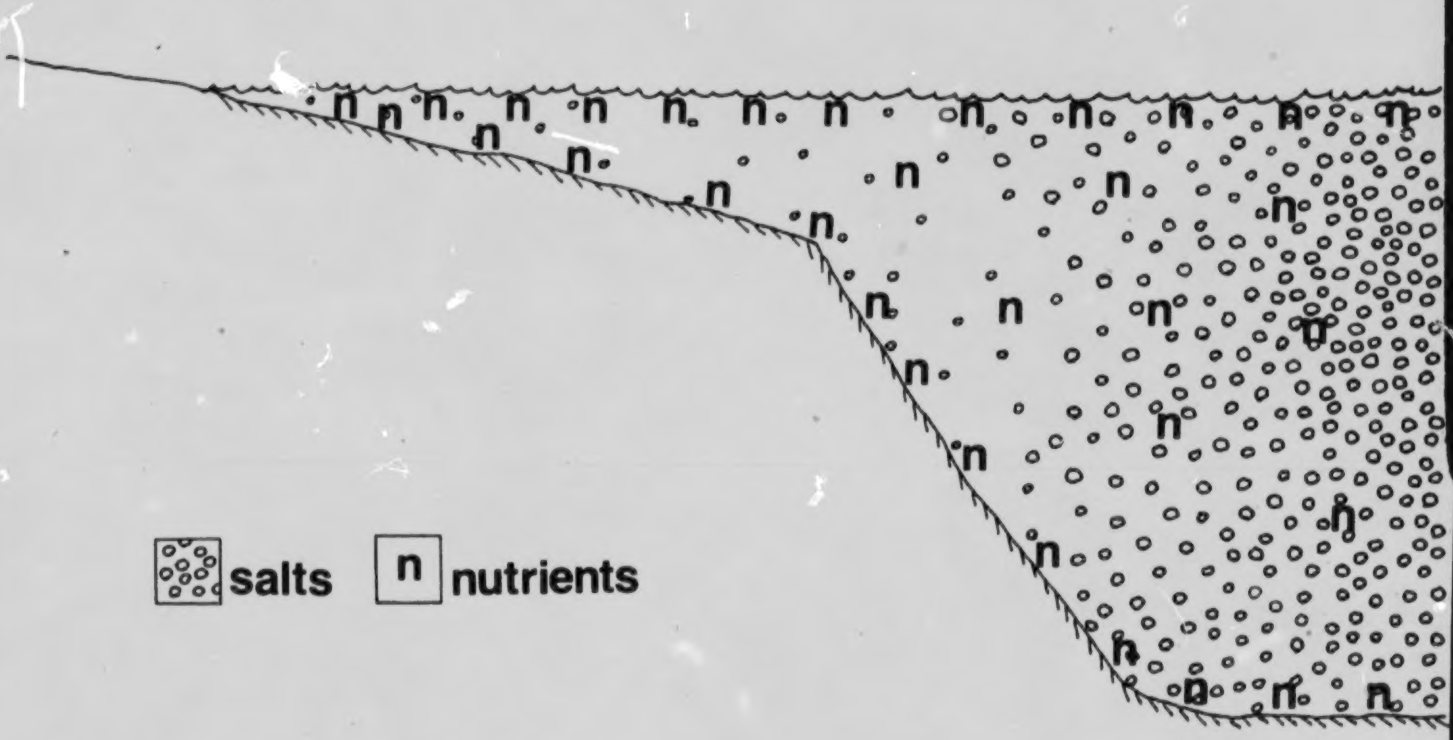
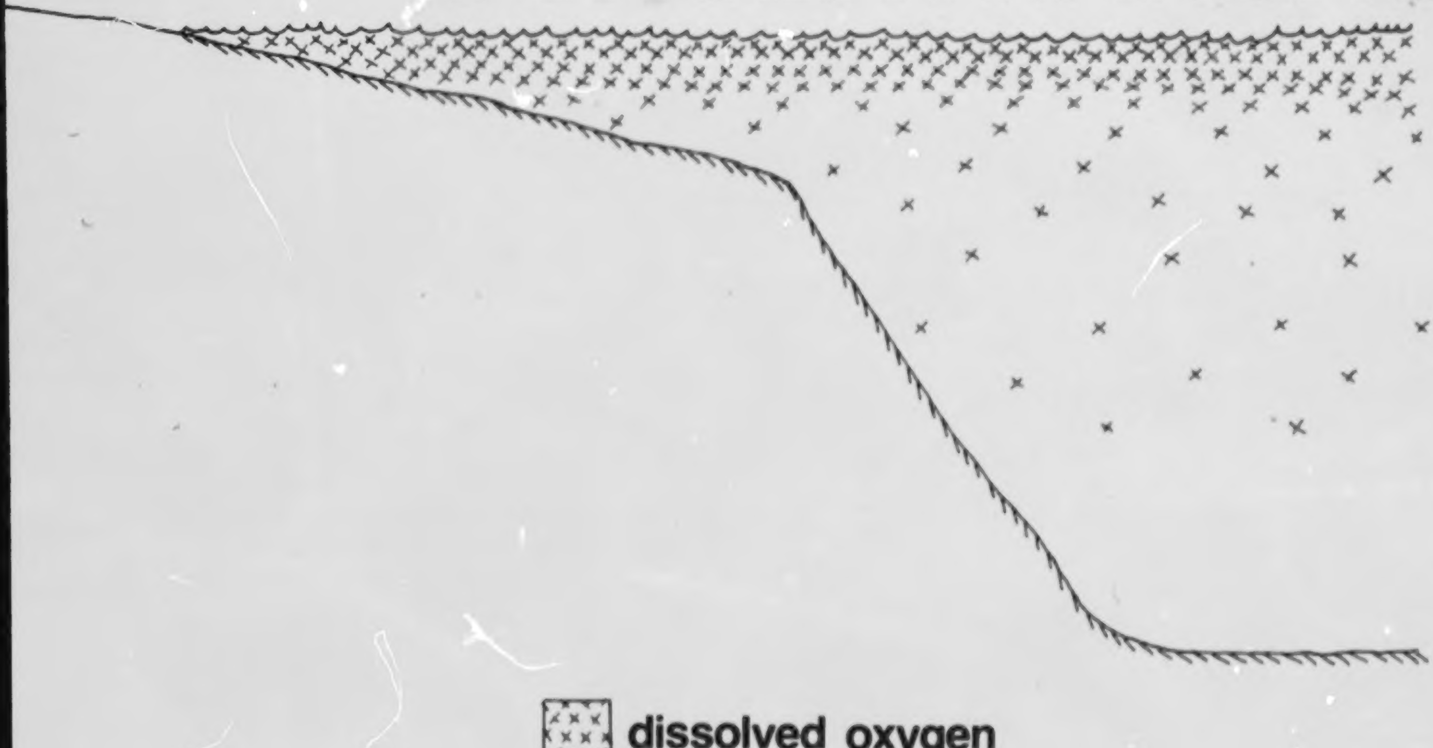

▨ salts
n nutrients

DIAGRAM OF

DISSOLVED OXYGEN CONCENTRATIONS


dissolved oxygen

MARINE ZONES AND ABIOTIC CHARACTERISTICS

Using the diagrams of the abiotic factors fill in the chart below.

MARINE ZONE	LIGHT	SALINITY	OXYGEN	NUTRIENTS	TEMPERATURE
OPEN OCEAN Above continental shelf			High near surface, decreases with depth		More variable than in open ocean beyond shelf
Beyond continental shelf				few nutrients in the open water	On surface varies with air-below lighten zone decreases with depth
SEA FLOOR Floor of continental shelf					Similiar to waters above
Floor of open ocean	no light is present				Similiar to waters above
INTERTIDAL		varies depending on river run-off evaporation precipitation			

Answer:

1. Why does the temperature vary greatly in the intertidal zone?

2. How would the temperature variation affect plants and animals of this zone?

3. What would cause the salinity of the intertidal zone and the open ocean above the continental shelf to change?

4. What effect would the amount of nutrients have on organisms? In which zone(s) are the most nutrients found?

5. Would the light have an effect on the kinds of organisms living in a particular zone? Explain.

6. Where is the most dissolved oxygen found? the least?

7. Would the amount of dissolved oxygen affect the organism? Explain.

TOPIC SIX
THE MARINE ENVIRONMENT AND MARINE ORGANISMS

BASIC GROUPS OF MARINE ORGANISMS

Read--

The Nekton
The Plankton
The Benthos.

Look at--

The sketches of the organisms in each group.

Look at--

The diagram of the distribution of marine organisms.

Divide--

A sheet of paper into five columns. Label them as follows:

Name of group
Organisms in the group
Plants, animals or both
Locomotive ability
Zones where found.

Fill in the columns.

Answer--

The questions on the groups of marine organisms.

Add--

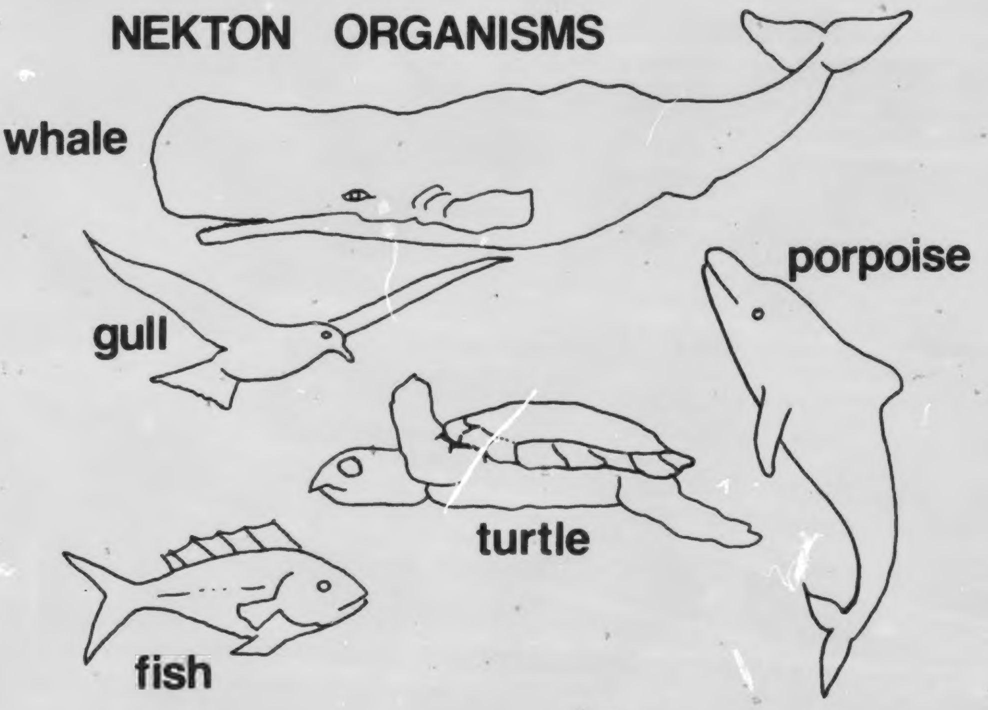
Representatives of the three groups of marine organisms to your mural of the ocean floor. You may draw the pictures, find pictures or cut out and color/paint pictures from the sketches of organisms in each group. Make sure that you place each organism in its proper zone.

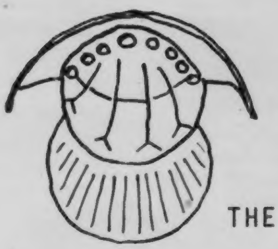
MARINE ORGANISMS

All life in the sea is grouped into three basic groups according to their locomotive ability and mode of living. These groups are the nekton, benthos, and plankton. I would like to introduce you to each group by asking a member of that group to tell us about their group.

THE NEKTON--by Charlie Fish

Hi! I'm Charlie Fish. I am a representative of the group of organisms called NEKTON. There are no plants in our group. We are strong swimmers, so we can move freely from place to place. The ocean currents or tides do not affect us. We are numerous in surface waters where food is abundant. We are not evenly distributed in the ocean but are found where our food is abundant. We decrease in number as you go deeper into the Gulf. Other members of the group besides us fish are the marine mammals (whales, porpoises, dolphins, and seals), sea birds, reptiles (turtles) and cephalopods, such as the squid. We can chase our food, flee if endangered, and cover large areas of water in our migratory journeys. However, our size, habit of gathering in schools, and our abundance over the sea make us the most important marine food resource available for harvesting by man.



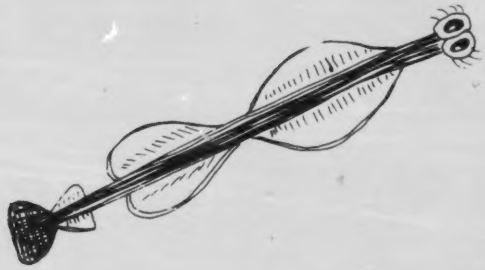


THE PLANKTON--by Phyllis Plankton

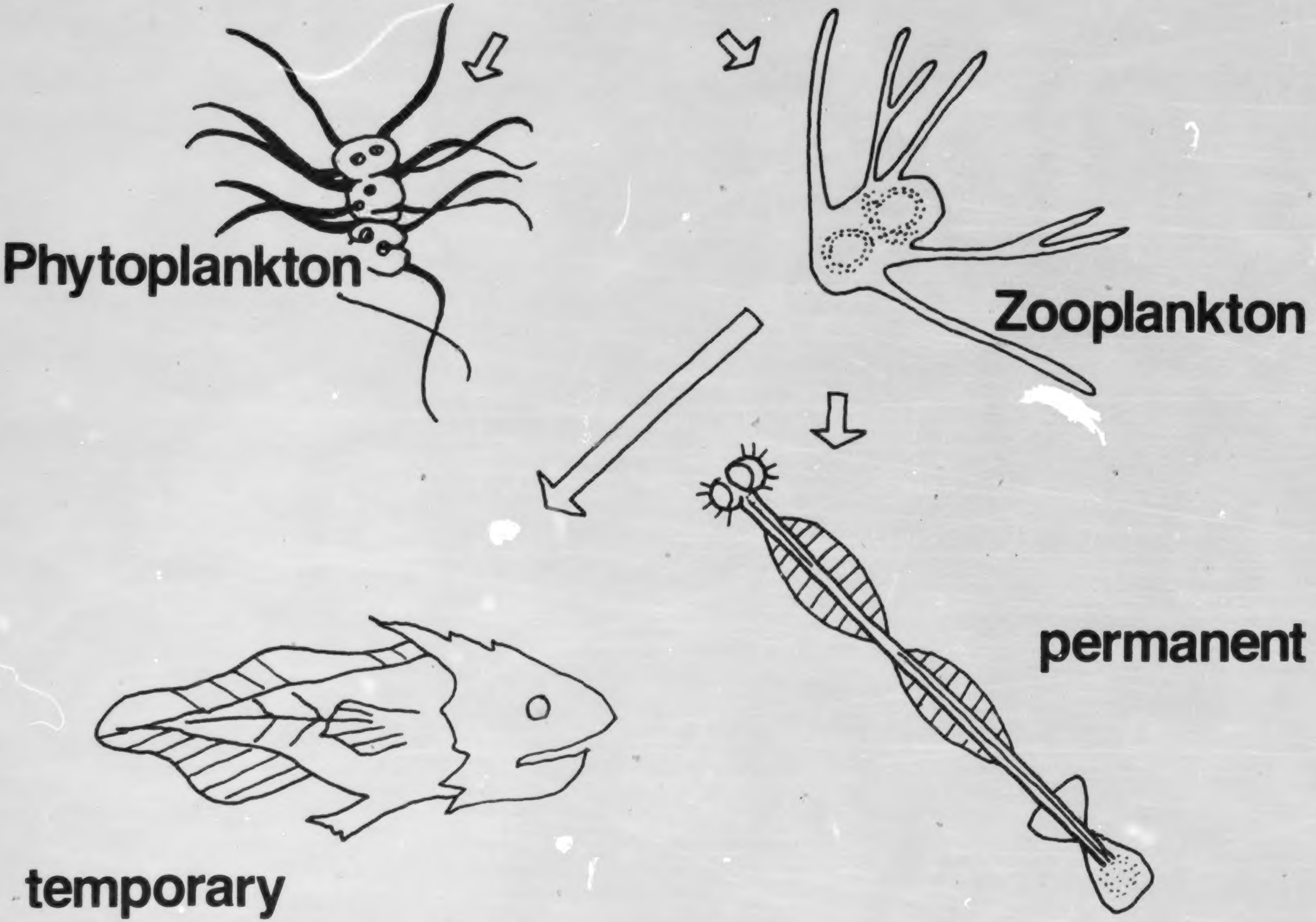
Hi! I'm Phyllis Plankton. We plankton exist in nearly every natural body of water throughout the world in such large numbers that we cannot be counted. We are mostly microscopic, but we are the most important organisms of the marine world. All forms of life either indirectly or directly depend on us. We are known as drifters since we wander or drift under the influence of the ocean currents and tides. Although many of us have the ability to swim, our efforts in the presence of ocean water movements are usually too feeble, therefore useless.

We can be divided into two groups: the phytoplankton and zooplankton. Phytoplankton means plant plankton. There are two main groups of phytoplankton: diatoms and dinoflagellates. All of us phytoplankton require sunlight to produce food, so we must live in the upper layers of the sea. We produce plant food and without us none of the animals of the oceans could exist. We also produce 70% of the oxygen in the world's atmosphere. We may be very small, but without us, there would be very little life on earth.

We, zooplankton or animal plankton, are strangely shaped with representatives from every major group of marine animals. We must stay in the upper layers of the sea to obtain food. Some zooplankton feed on phytoplankton while some eat each other. We are composed of temporary and permanent members. Our permanent members are those of us who spend our entire lives as plankton. These are the protozoans (formanifera, radiolarians, tintinnids) siphonophores, ctenopheres, some rotifers, and crustaceans which are the most abundant. Our temporary members are those who only spend part of their life as drifters. They are the larvae of sponges, corals, worms, mollusks, echinoderms and fishes. When they become adults, they become either the nekton or benthos.



PLANKTON



Phytoplankton

Zooplankton

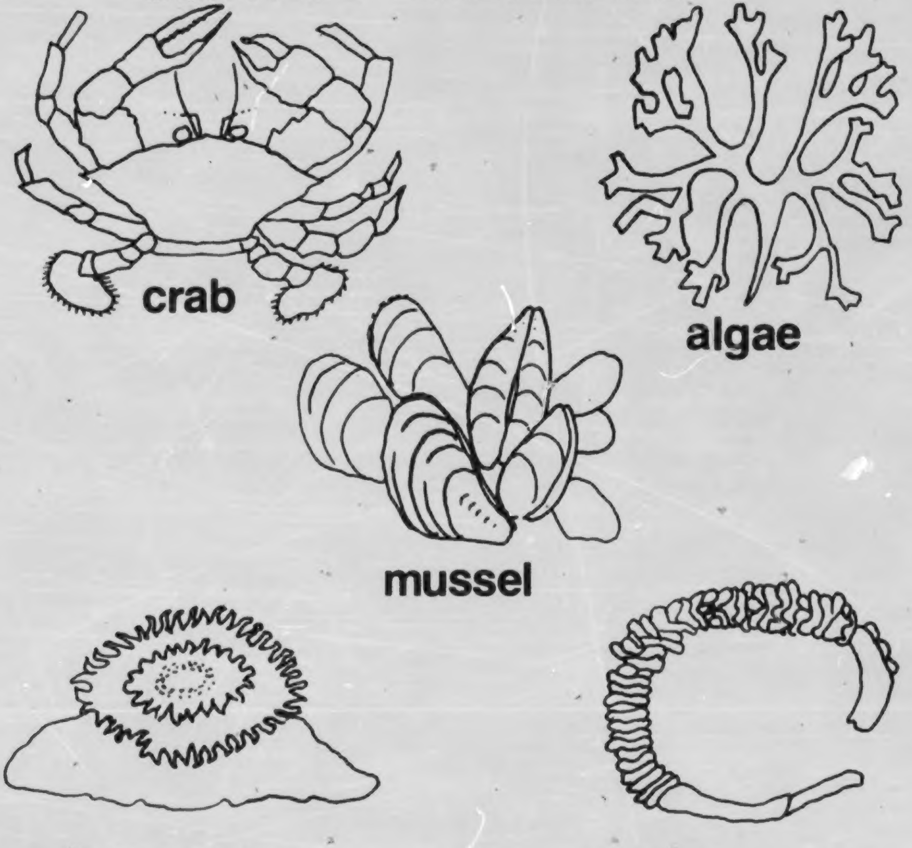
permanent

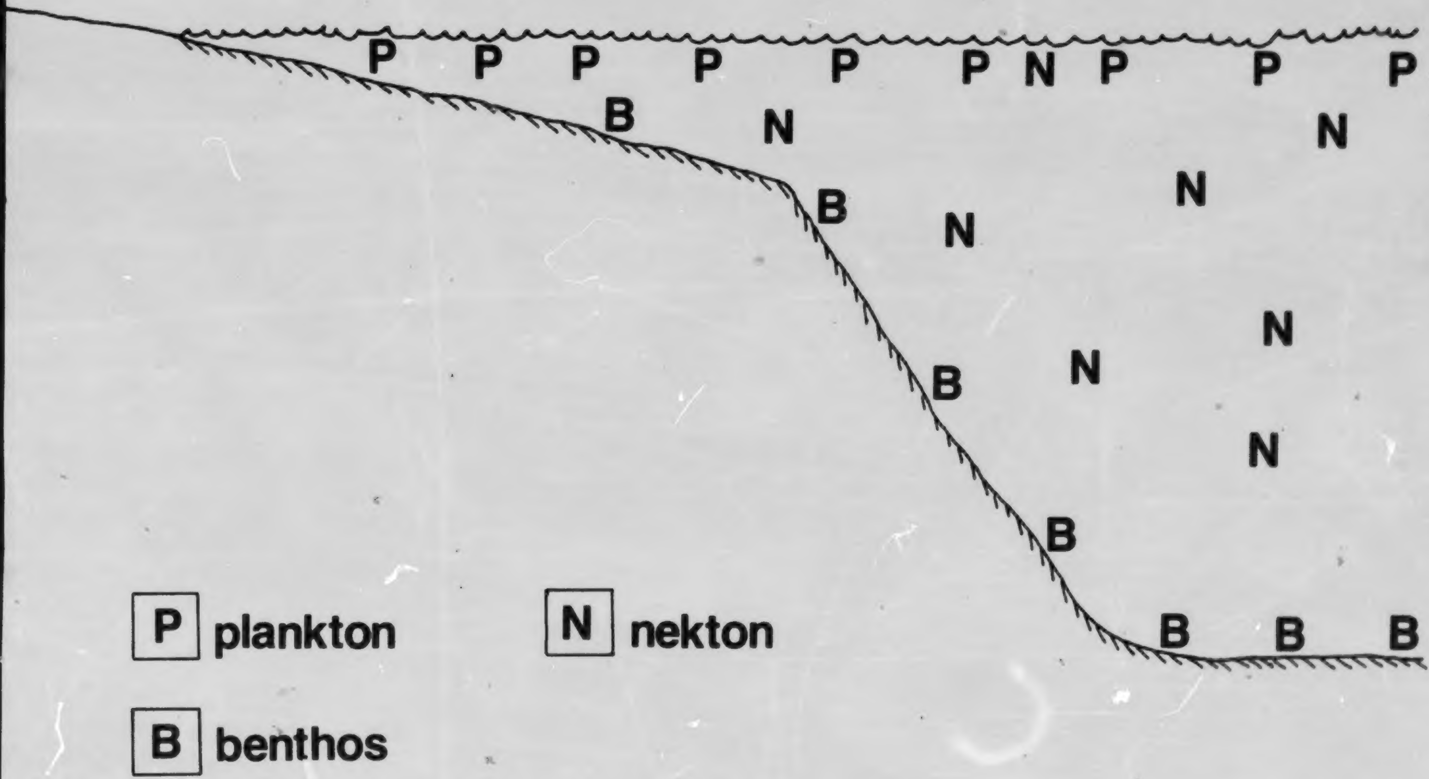
temporary

THE BENTHOS--by C. Crab

Hi! I'm C. Crab. I am a representative of the Benthos group. We live on the bottom. Our group has both plants and animals. Temperature, dissolved oxygen, depth of bottom and the kind of bottom (mud, sand, rock) determines which one of us you will find in an area. Some of our group remain attached to the bottom like the sponges, barnacles, oysters, mussels, corals and bryozoans eel grasses and the sea weed (algae). Some of our group creep or crawl along the bottom like me, other crabs, osopods, snails, shrimp, some bivalves and crustaceans, but not plants. Some of our group burrow into the sediments like most clams, worms, some crustecea and echinoderms. At present not much is known about those of our group who live on the bottom of the deepest parts of the ocean. We know that worms, sea cucumbers, shrimplike creatures and brittle stars exist on the bottom at all depths.

BENTHOS ORGANISMS




P P P P P P N P P P
B N N
B N N
B N N
N
B
B B B
P plankton
N nekton
B benthos

Questions on the groups of marine organisms.

You may wish to refer back to the diagrams of abiotic factors, zones of marine environment, distribution of marine organisms, and your chart to help you answer these questions.

1. Which organisms are found in more than one zone?

2. Why are the plankton found in the surface waters?

3. Where do you find the benthos? Why?

4. How does each group get its food?

5. If we dredge the bottom of the shelf which group is affected?

6. Why could the plankton be called the smallest but mightest?

TOPIC SIX
THE MARINE ENVIRONMENT AND MARINE ORGANISMS

INTERTIDAL ECOSYSTEMS

Look at--

The profile of the areas of the intertidal zone.

Look at--

Sketches of the intertidal ecosystems.

Label--

Each of the ecosystems on the mural of the ocean.

Read--

Marine Ecosystems of the Gulf Coast
Rocks, Jetties and Groins
Sandy Beaches
Oyster Reef
Salt Marshes
Mud Flats
The Water, Itself.

List--

Some examples of biotic factors in an ecosystem.

List--

Some examples of abiotic factors in an ecosystem.

Prepare--

An interview or skit with some of the organisms in each area of the intertidal zone to present to the class. Include in the interview or skit information about the:

(1) abiotic factors
(2) biotic factors
(3) interaction between the biotic community and the abiotic factors.

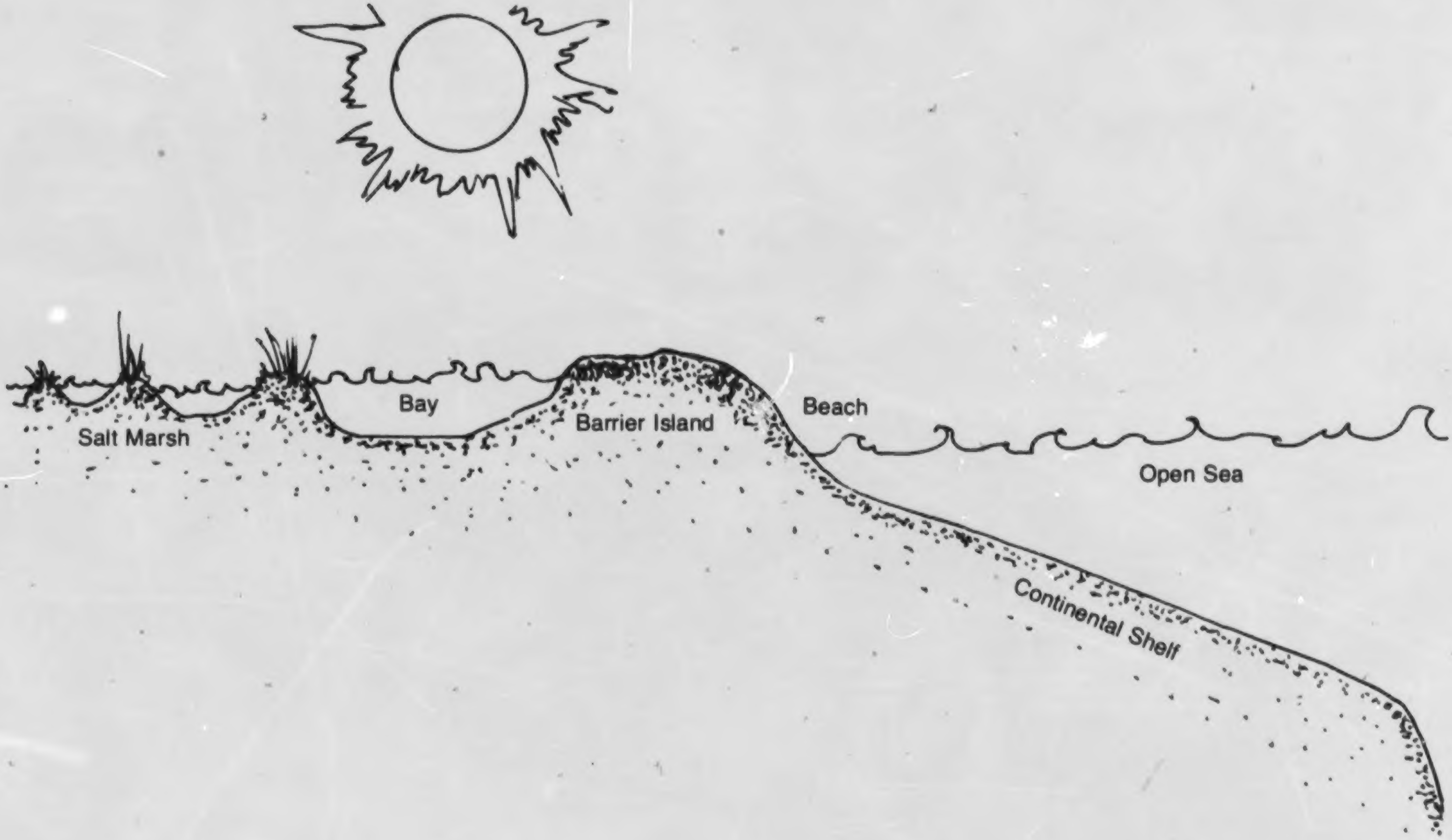
Present--

Skit or interview to the class.

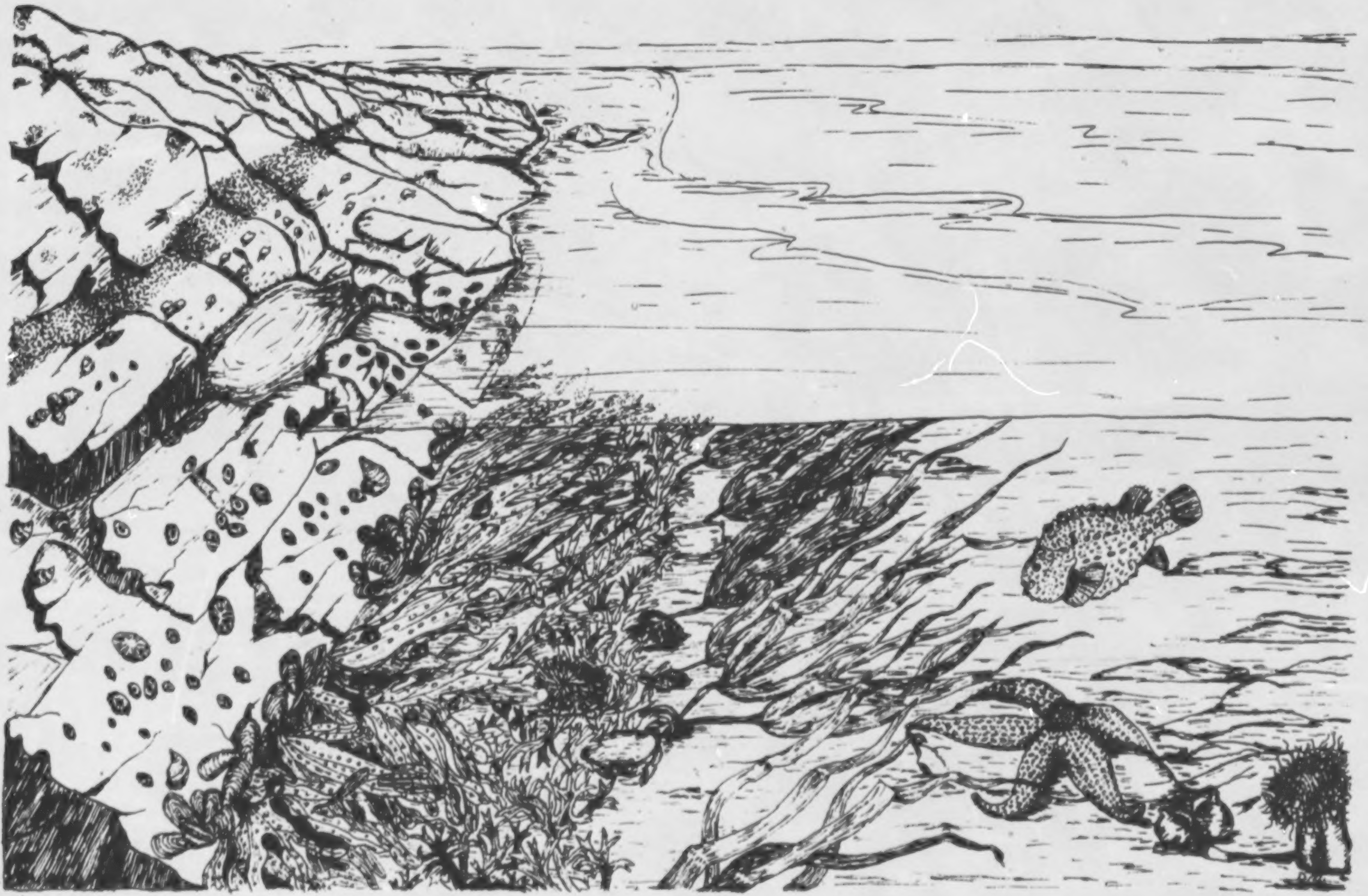
Add--

The intertidal zone and organisms found in each to your mural of the ocean.

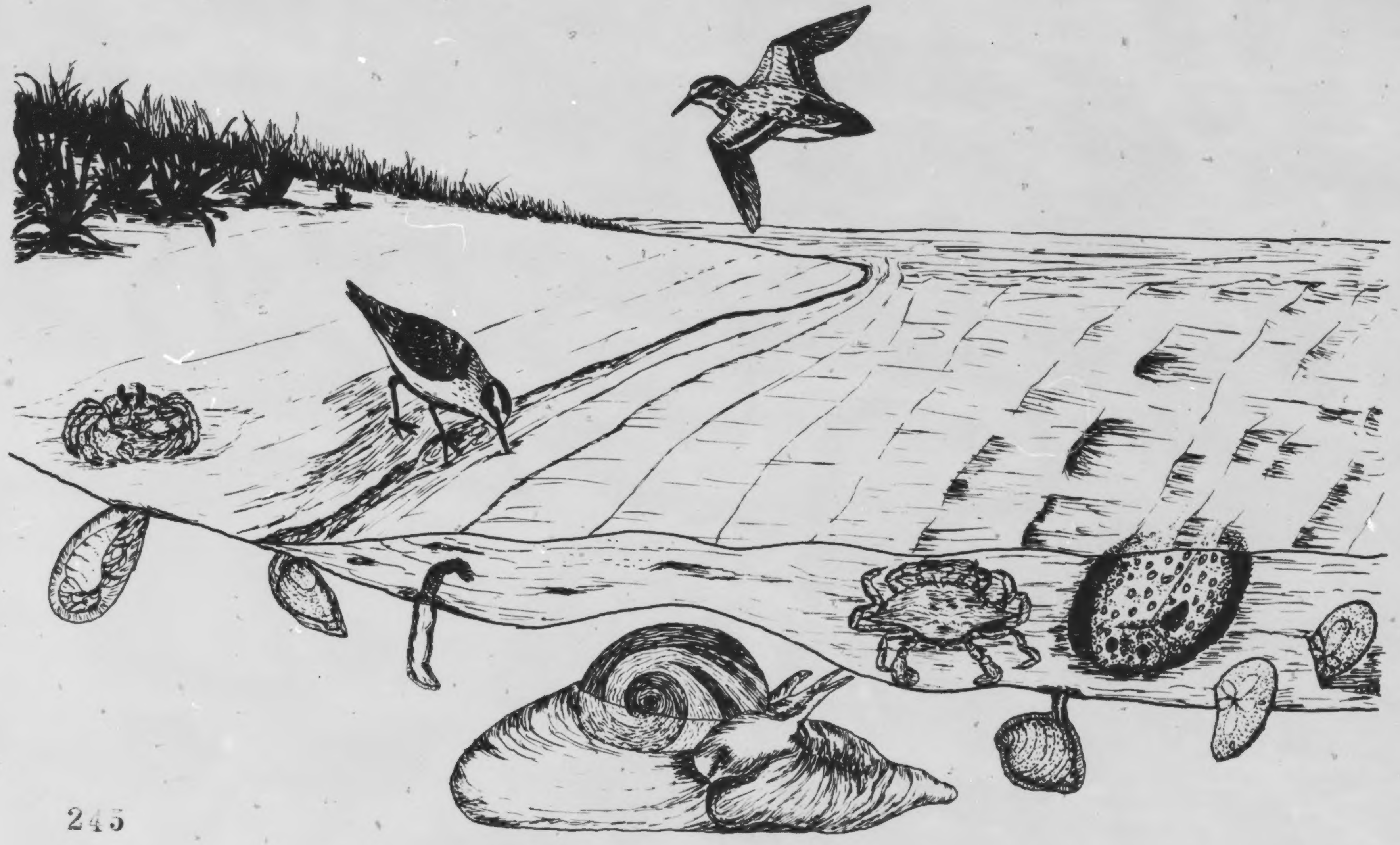
INTERTIDAL ECOSYSTEMS


Salt Marsh
Bay
Barrier Island
Beach
Open Sea
Continental Shelf

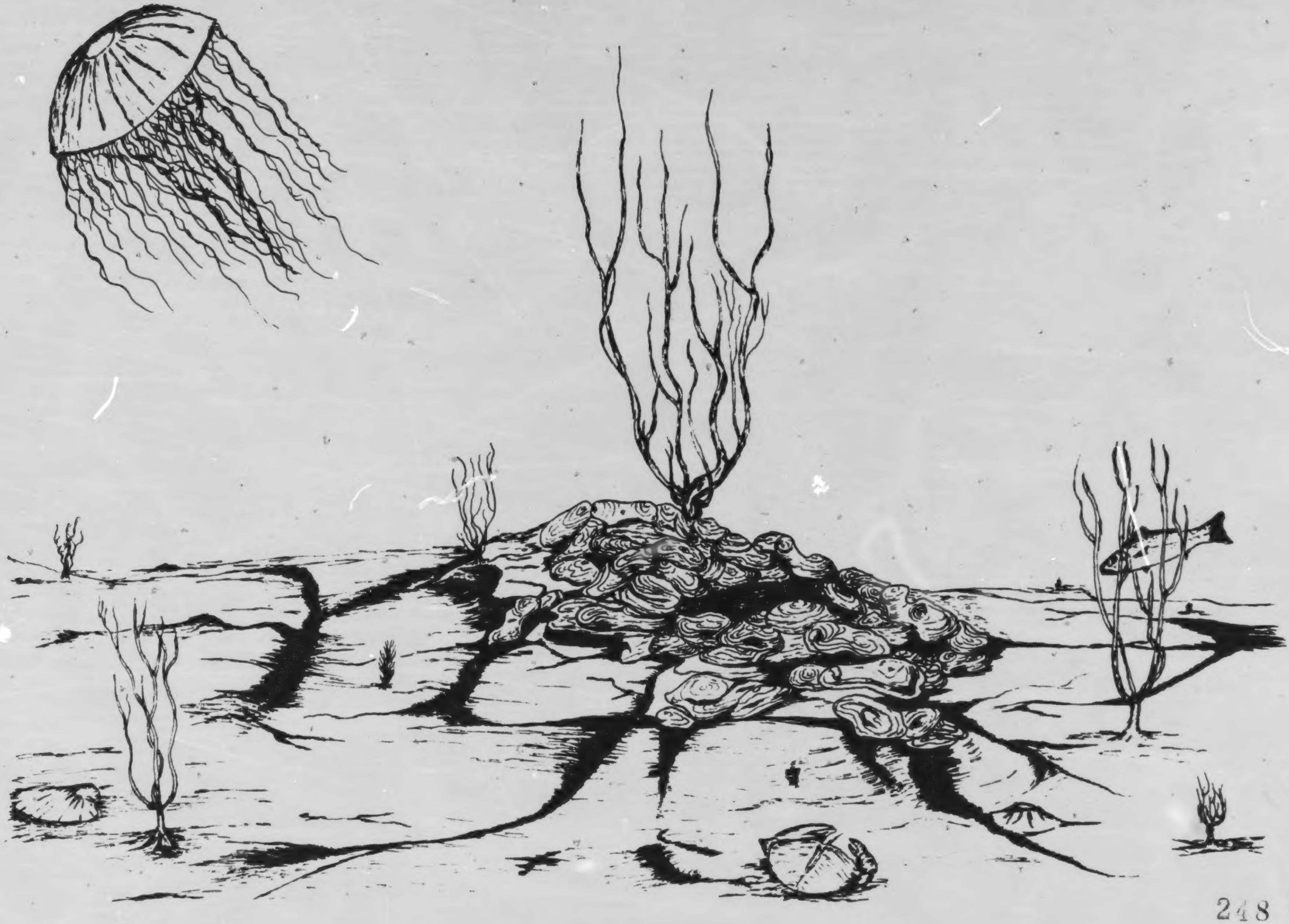
ROCKY SHORE



SANDY BEACH



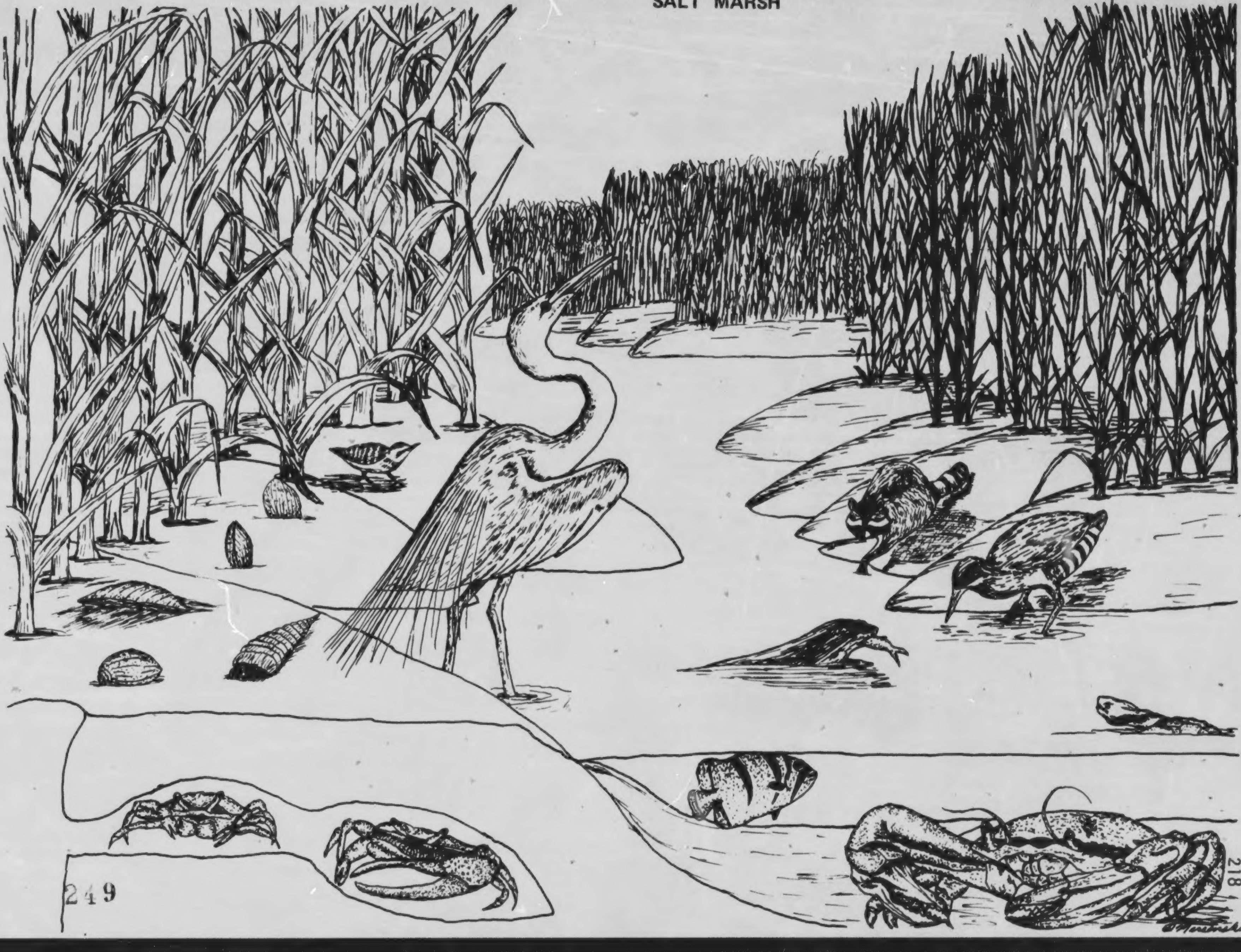
OYSTER REEF



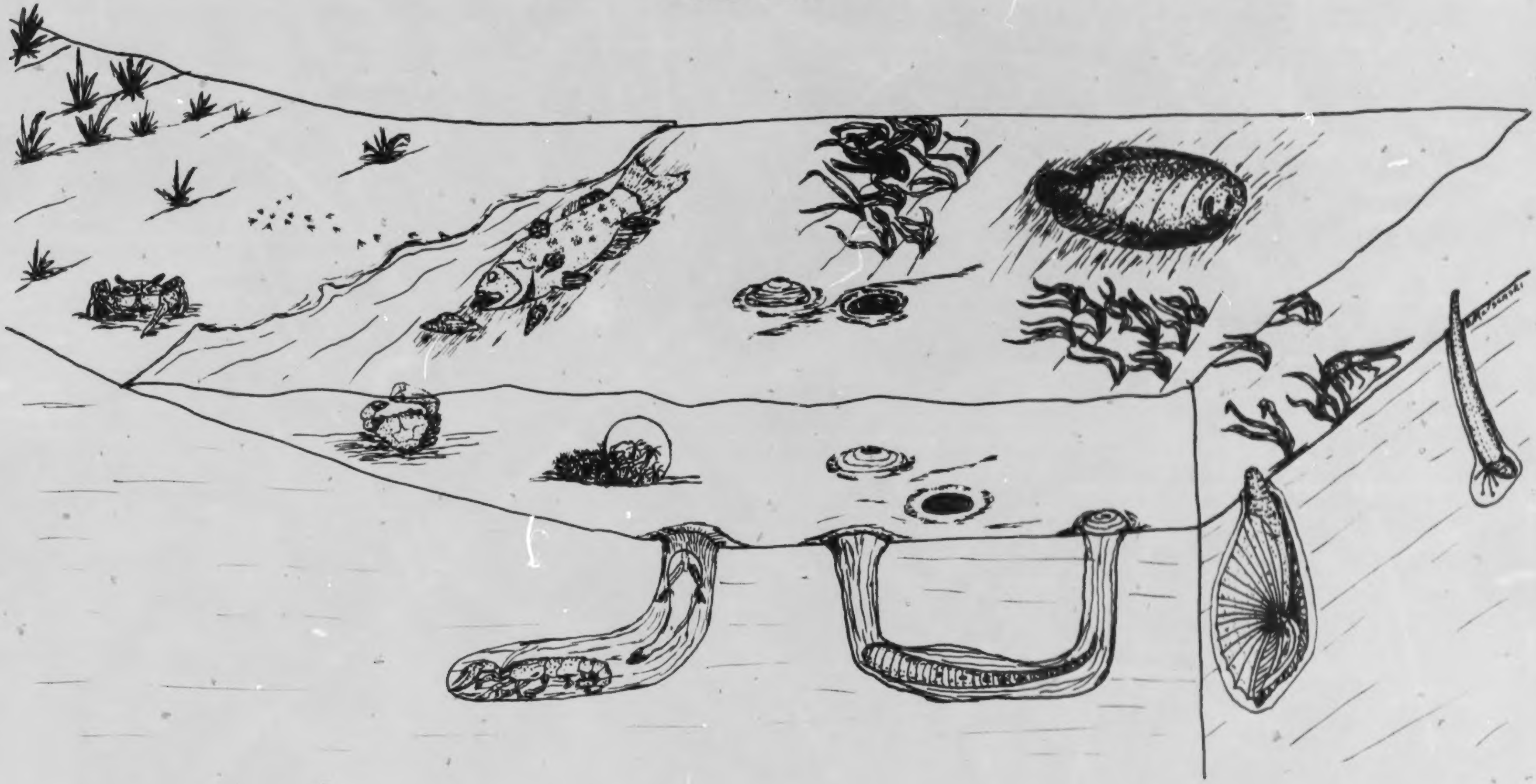
247

248 217

SALT MARSH



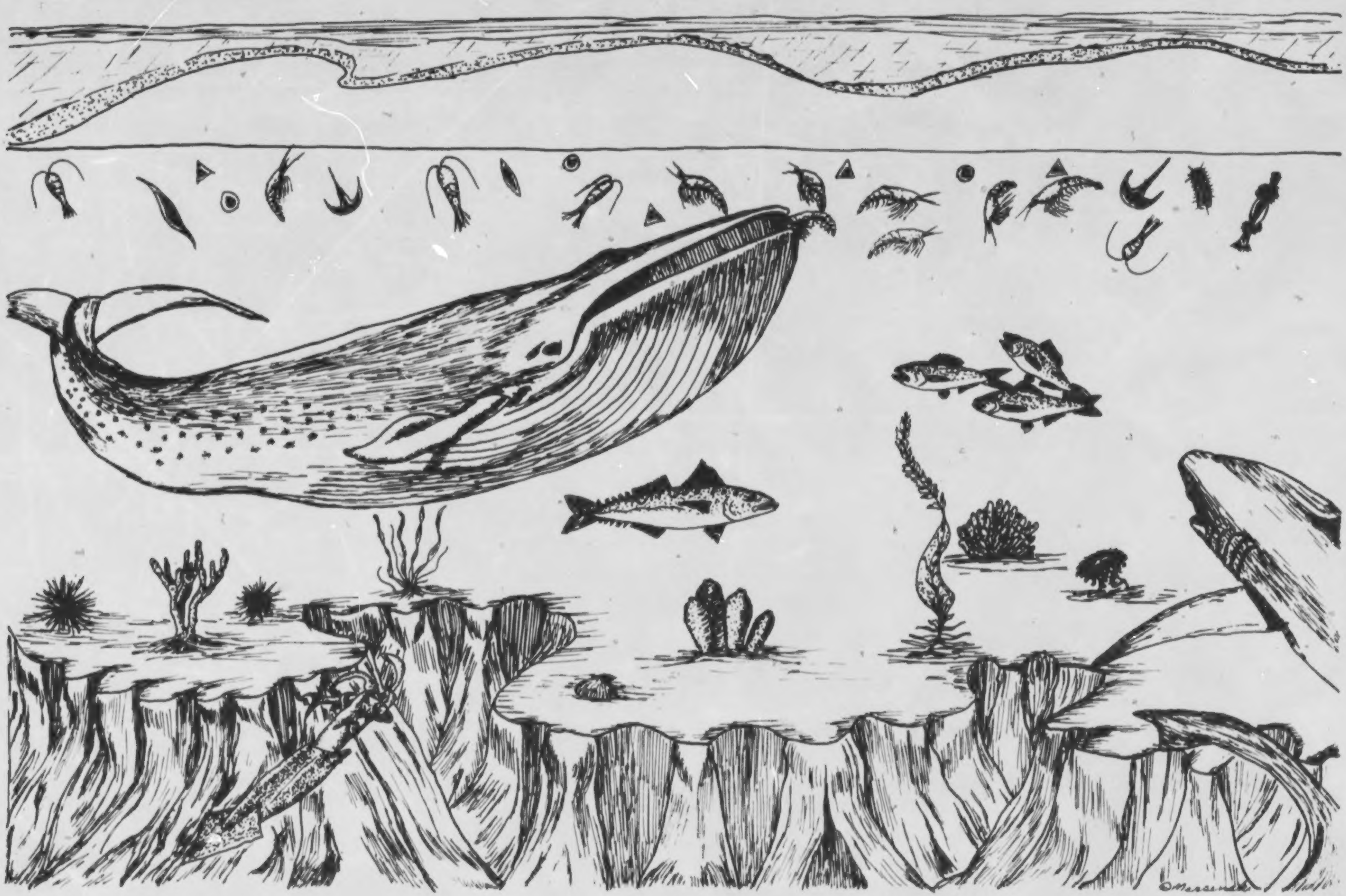
MUD FLAT



251

252

OPEN WATER---CONTINENTAL SHELF



MARINE ECOSYSTEMS

The land environment as well as the marine environment is composed of many ecosystems. Ecosystems are the interaction of the living organisms (biotic) and non-living physical and chemical factors in a particular location.

The intertidal zone consists of numerous marine environments. If we look at the map of the Gulf of Mexico along the Texas coast we see a series of barrier islands enclosing shallow bays. These form environments which differ in the base where the organism lives, exposure to surf, food resources and the degree that the environment varies. We shall separate these into the following ecosystems: rock jetties and groins; sandy beaches, salt marshes, oyster reefs, mud flats and the water itself. The sandy beaches and rock jetties are on the outer coast. The mud flats, salt marshes, and oyster reefs are the major types in the bays.

The jetties and groins were designed to interrupt the flow of sand along the shore to reduce the erosion of beaches and depositing of sand in the navigation channels. So this ecosystem is subjected to breaking waves with sand, strong currents and changing sand levels. The sandy beach organisms are also subject to surf, currents and shifting sand.

The barrier islands protect the bay ecosystems. The bottom is muddier due to fine particles from the rivers and bayous settling to the bottom. They are also shallower so they heat and cool faster and undergo more sudden changes in salinity and oxygen content. The oyster reefs are composed of organisms which depend heavily on the food-carrying currents so depth is not as critical as it is for the mud flats or salt marshes.

All the ecosystems of the Gulf Coast have a highly variable climate. Hurricanes, northers, floods and freezes are sporadic events that may have tremendous effects on the organisms. Animals living near the waterline risk exposure to large and often abrupt changes in temperature, salinity and water level caused by these events. Hurricanes and severe thunderstorms dump enormous amounts of water on the coastal zone. This large amount of fresh water will reduce the salinity for several days and raise the water level. Northers blow surface water away from the coast and reduce the air temperature, chilling the organisms.

ROCKS, JETTIES AND GROINS

Many areas have rocky shores, but on the Texas coast there are no natural rocky areas. The Texas rocky shores are jetties and groins that were made by man to control the movement of sand along the shore.

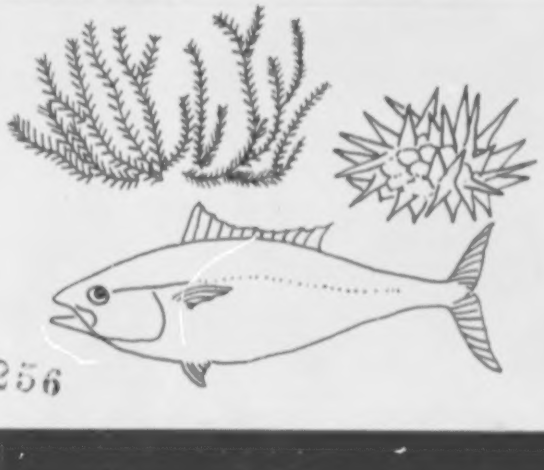
This is the only area with a solid subtrate where algae (seaweed) can grow. The marine algae is rather limited, possibly because of the predominately sandy and muddy shore and the great variations in temperature and salinity. The red algae are greatest in abundance and number of species, followed by the green algae. Brown algae, such as kelps, are absent and only a few other brown algae are found. If it were not for this man-made environment, there would be very few algae on the Texas Gulf coast.

The animals on the jetties include the acorn barnacle, zebra periwinkle, false limpet, rock louse, hermit crab, stone crab, porcelain crab, the drill sea anemone, peppermint shrimp, sea hare, sea urchin, beach flea, hydroid, stony coral, fan worm, jackfish and spadefish.

Most of the animals on the jetties either filter plankton from the water, eat algae or diatoms that grow on the rocks, or search for scraps of food left by the tide, gulls, or fishermen.

The jetty environment requires hardy individuals to survive its harsh conditions. They must survive the stress of: (1) breaking waves and sand, (2) strong currents, (3) changing tides, (4) sudden changes in temperature and salinity, and (5) exposure to the sun and wind.

The jetty inhabitants do have common features with other rocky shore organisms around the world. They live in definite vertical zones. On top of the jetties there is the splash zone or suppralittoral which is wetted only by the spray of the breaking waves. Below this is the zone which is submerged during nearly all high tides and exposed during nearly all low tides - the littoral or intertidal zone. Below that is the zone only uncovered by the lowest tides - the sublittoral zone.



SANDY BEACH

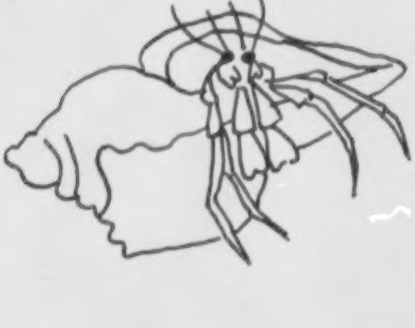
The beach is also a harsh environment for organisms. The factors they must deal with are pounding surf, abrasive sand, periods of wetness and dryness, temperature changes and exposure to the sun. Most sandy beach animals escape physical factors of their environment by burrowing. Much of the community lives underground out of sight, and some species move up and down the beach with the tide.

The beach can also be divided into vertical zones. In the zone of the dunes to the high tide level we find the plants: silvery beach croton, waving sea oats, railroad vine, sea purslane, yellow beach evening primrose, and others. In this area some of the animals are rattlesnakes, lizards, spotted ground squirrels, kangaroo rats, grasshoppers, mice and other rodents like gophers and rats.

The supralittoral zone begins at the base of the dunes to the high tide line. The ghost crab is the most obvious animal of this area. He is a scavenger eating dead fish and the remains of animals found on the beach. The tiger beetles are another common resident

The surf zone between the tides (littoral-high and low tides) is inhabited by the bean clam, mole crab, lettered olive and moon snail, hermit crab, auger shell, and tube building worms. Since many intertidal animals are hidden because of their burrowing, a good clue to their abundance in an area is the presence of feeding shore birds like sandpipers and sanderlings.

In the zone below low tide level (sublittoral) we find the sand dollar, Scotch bonnet, starfish, sea star, sea pansey, yellow and purple sea whips, calico crabs, blue crabs, and other crabs, murex, banded tulip, clams, many species of shrimp, octopus, and fish such as trout, redfish, drum, gaftop, pompano, croaker and others.



THE OYSTER REEF

The oyster reef community is an important biotic community in the bays. The commercial oyster is found in almost every Texas bay. None live in Laguna Madre, but scattered reefs exist in South Bay near Port Isabel.

The reef is more than a collection of oysters. It is a community of many plants and animals. Other animals use the reef as a hiding place, a source of food, or both. These plants and animals attract small fish. The small fish attract larger fish and these, in turn, attract the fisherman.

Oyster reefs are groups of living animals growing on the graveyard of their ancestors. They form very slowly over a long period of time. The life of the reef is related to the organisms forming it. When they die the reef also dies and becomes buried in the mud. Whenever the conditions favor the growth of oysters, a reef may be formed. Firm bottoms of sticky mud, clay, sand, or gravel are needed. At first a few oysters attach to the bottom. The next generations attach themselves to these oysters and the dead shells. A reef forms. The formation of the reef depends on the direction of water currents. The oysters depend on these currents to bring in their food, the plankton. The oysters nearest the current, therefore closest to the food, grow fastest and are first reached by larvae. The reef grows facing the current.

Oysters grow very well where the fresh waters of streams mix with the salt water of the Gulf so they are found in the bays of tidal rivers. They can survive a wide range of salinity, from fresh water for brief periods to waters saltier than the Gulf. Freezing temperatures will affect the oyster if it is exposed in shallow water. Temperatures over 90°F for a long period of time weaken the oysters. The greatest hazard to the oyster reef is the settling of clay or mud. A small amount may interfere with the feeding, and large amounts will smother and bury the reef.

Some members of the reef community are competing with oysters for food or places to attach. These are the mussels, anemones, barnacles, slipper shells and the serpulid worm.

Many inhabitants of the reef are oyster predators like the drills, the stone, blue and mud crabs, flatworms, snails and boring sponges. Some animals like small snails, porcelin and oyster crabs, sea squirts and pen shells use the reef as a shelter.

SALT MARSHES

A wedding of the land and the sea gives birth to the salt marsh. The marsh begins to form when waves shape sand into offshore barriers. Tidal creeks cut through these protective barriers, flooding the area behind them daily with sea water. In this area, protected from the battering waves, cordgrass grows. Its dense growth slows the tidal currents so they drop their load of material to form a floor of nutritive mud.

The salt-tolerant grasses of the marsh produce vast amounts of organic material by photosynthesis. The salt marshes are among the most organically productive areas on earth. Only tropical rain forests, coral reefs and some algal beds produce more. The best farmland produces only half as much life as the salt marsh.

The salt marshes, fed by both salt and fresh water, are the nurseries for many marine organisms as well as nourishing myriad creatures of sea and land. Nearly all commercially valuable seafood owes its existence directly to the marsh. This ecosystem is a factory for human food.

The stands of cordgrass are a prominent feature of the salt marsh. Many animals seek refuge on and among its sturdy stalks. One of the most abundant is the marsh periwinkle which climbs the cordgrass to escape the rising tide. When the tide recedes, it descends and crawls about on the mud grazing on plant matter and other detritus. The marsh snail, horn shell, mussels and worms are also in the mud at the base of the cordgrass. The stone crab is present, cracking open clam, snail and hermit crab shells for a meal.

The fiddler crab, sifting through the mud and sand for edible material, is one of the most common crabs in the salt marsh. The marsh crabs, pulmonate snails and amphipods also use the debris for food. Land crabs are present in the salt marsh.

The tidal creeks of the marshes are the nurseries for the young of many species of crustacea (shrimp) and crabs and fish. Some species of fish spend their entire life in the area while in other species only the young do. Phytoplankton, plankton, and planktonic larva are also present. The grasses, phytoplankton, and mud algae are the key producers of the salt marsh.

Among the marine animals, only a relatively few can adjust to the rapid salinity changes which occur in the salt marsh. The marsh vegetation supports many migrants. This includes such mammals as the opposum, mouse and the raccoon who visit the water's edge to eat mussels and crabs. The muskrat is a permanent resident in the less saline parts where its food, such as bulrushes and cat-tails, is abundant. The deer also visits the marsh to graze.

The diamond back terrapin lives in the marsh. It feeds on dead fish, marine worms, fiddler crabs and small mollusks.

Many species of birds may be found in the salt marshes. However, only a few species are characteristic of the salt marsh and either reproduce there or frequent it often. The common ones are certain rails, sparrows, ducks, teals, certain shorebirds, marsh hawk red-wing blackbird, marsh wren, herons and bitterns.

The salt marsh is where the incoming tide stirs up nutrients and recharges stagnant pools with oxygen. Organisms ride in with the tide. As the tide recedes, it flushes out dissolved material and carries decaying plant material as well as living plants and animals to join the offshore food web. Birds move in to eat creatures left exposed on the mud. This makes the salt marsh a cradle of life for an estimated 95 percent of all fish and shellfish landed by sport and commercial fisherman along the Gulf coast.

MUD FLATS

Large areas of the shallow Gulf coast bays are covered by only a few inches of water at low tide. These areas are too shallow for the forming of salt marshes. These are the mud flats. They are not flat, however; the bottom is shaped by currents, waves and burrowing animals.

The mud flats are often exposed during extreme low tides and northers. They are best suited for burrowing organisms or very motile ones. The organisms also vary from one area to another since the bottom varies. The bottom is sandier near the passes and in channels cut by currents.

In the sandy mud there is the stout razor clam who is a deposit feeder. Its enemies include the drill, the blue crab, the hermit crab and various shorebirds. There are also the jackknife clam and the fragile angel wing. The common rangia is a true estuarine species since it is found well into the months of rivers and bayous. There is also the dwarf surf clam which is eaten by bottom-feeding fish. The constricted macoma and southern quahog are two clams that are also in the mud flats along with mud shrimp and ribbon worms.

The mud crab, flat mud crab and large stone crabs are at home in the mud flats. The burrows of the large stone crabs play an important role in the mud flat ecology. During low tide these burrows provide the mud crabs, hermit crabs, grass shrimp, snapping shrimp, worms and several species of fish a shelter from the drying sun and foraging shorebirds.

In the sandier mud flats, near the passes, there are the bright red nemertean, moon snail, baby's ear, the common mud snail, common Atlantic auger and the oyster drill. There are also three species of hermit crabs. Many polychaete worms as well as the parchment worm and lugworm are at home in the mud flats.

There are also submerged beds of widgeon grass on the mud flats. This grass helps to stabilize the sediments and provide food and shelter for organisms. Some of these organisms are the grass, arrow and snapping shrimp. Another grass community in the mud flats is the turtle grass. In the turtle grass there are pink and grass shrimp, mud crabs, thick lucine, cross-barred venus, and the bay scallop. The sea cucumber, virgin nerite, whelks, tusks and bubble shells are also found in the mud flat areas.

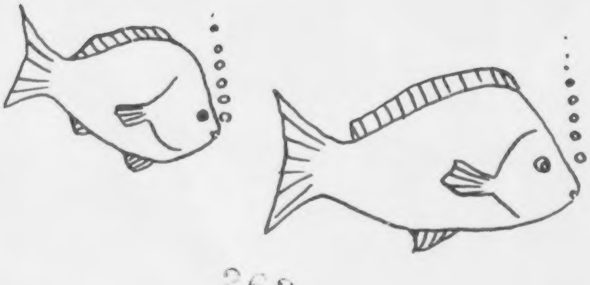
THE WATER, ITSELF

The water itself forms an additional community for swimming and floating organisms, in the bays, passes and beach water. These include plankton and nekton. The plankton change with the seasons since they are very sensitive to minor changes in temperature, salinity, oxygen level or toxin in the water. The larvae of most marine animals are plankton and so are usually seasonal in their appearance.

Some of the permanent plankton are the copepods, etenophores, arrow-worms and sergestid shrimp. Some of the larger plankton are the cabbabe heads, moon and other jellyfish, sea nettle, sea wasp and sea walnut. Other animals such as spider crabs, and blue crabs may hitch rides in the jellyfishes' bells.

The most obvious invertebrate nekton are squid, shrimps and swimming crabs. The majority of the nekton are the fishes, but there also are the sharks, rays, skates and dolphins.

The waves washing up on the beach often carry organisms which normally live in deeper water or drift out in the Gulf. Some of these are the Portuguese-Man-of-War and purple storm snail. Most of these are usually dead or battered. The flotsam (driftwood or non-living objects afloat) carry several species. These are the stalked barnacles and boring clams. Sargassum, a floating seaweed, is brought in by the currents also, and washes on the beach. The sargassum brings with it many animals who live in its branches. These include hydroids, anemones, flatworms, polychaetes, shrimp, crabs, nudibranch, sargassum fish and the young of other fish.



TOPIC SIX
THE MARINE ENVIRONMENT AND MARINE ORGANISMS

MARINE ORGANISMS--LET'S GET ACQUAINTED

Complete--
The underwater life activity (finger painting).

Display--
Your painting.

Write--
A syntu about a marine organism.

Share--
Your syntu with your classmates.

Begin--
The Marine Life Along the Coast of the United States activity.

Complete--
The Let's Get Acquainted activity.

Share--
Your marine mammal's face with your classmates.

Read and answer
Name the Animal.

Read--
An article on a marine organism.

Design--
Your own "Name the Animal" paragraph based on your reading.

Read--
Your paragraph to the class and see if they can identify your organism.

Read and discuss--
Specially Designed .

Complete--
Design a Beak activity.

Share--
Your beak designs with your classmates.

Make--
A Gyotaku (fish printing).

MARINE ORGANISMS--LET'S GET ACQUAINTED

Make--
A mobile using shells or marine organisms.

Display--
The Gyotaku prints and mobiles.

Optional

Obtain--

Samples of clams, oyster, scallops, mussels, lobsters, shrimp, crabs and fish that are fresh or frozen for dissection.

Dissect--
The specimens.

Remove and cook--
The edible parts--in other words eat your dissection.

UNDERWATER LIFE ACTIVITY

You will need the following materials: finger paint paper, finger paints, especially blue and green, can of water, sponge and newspapers.

Sponge the shiny side of the finger paint paper with water. Place about one teaspoon each of blue and green finger paint on the wet paper. Spread and blend the colors with large movements. The colors will get muddy with too much rubbing. With fingertips, design an underwater scene, including fish, plant life and etc. Use books & etc. to make sure the environment and organisms are correct in size, appearance, location and in all aspects.

Some variations which you might want to try. Blend the finger paints on the wet paper for the watery effect. Let the paint dry. Then glue the painting to a piece of cardboard. Cut out small fish from foil and glue them to the painting. Glue dried grasses, shells, pebbles and sand to the picture and cover it with plastic wrap. Again make sure your picture is accurate.

Make a sketch of the plans for your Underwater Life painting below.

SYNTU ABOUT A MARINE ORGANISM

Write a syntu about a marine organism. A syntu is a Japanese poem consisting of five lines. The lines do not have to rhyme. The lines are as follows:

In line 1 use one word--the name of a marine organism

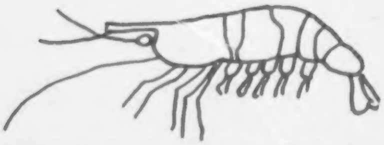
In line 2 write an observation of the marine organism you named in line 1 using one of the five senses.

In line 3 write a feeling about the item named in line 1.

In line 4 write another observation of line 1 using one of the senses not used in line 2.

In line 5 write a one-word synonym for line 1.

Write your syntu below



MARINE LIFE ALONG THE COAST OF THE UNITED STATES

Use a large wall map of the United States. Select a coastal area (town or city) on the map
about especially the marine environment and its organisms. The area you selected is ______________________________.

Once you have selected your coastal area, compose a letter to the chamber of commerce of that town. Ask the chamber of commerce for information about the area and the names and addresses of the junior and senior high schools in the town/city.

Once you receive the names and addresses of the schools. Compose a letter to the science department of several of the schools. Ask them to send you a sample of the shells and maybe a few sample marine organisms from their coastal area.

When the samples arrive put a part of the sand in a clear plastic bottle and label it as to its location. (The remaining sand can be put into a container, labeled and stored for further studies and investigations.) If the algae is not mounted, identify, label, dry and mount it. Label and identify all the shells and other marine organisms.

Place a large map of the United States on a wall. Attach the samples to the map so your classmates can see the variations and similarities among the sand shells and organisms from the different coastal areas. Note if there is a relationship between the sand color and the organisms found living there.

LET'S GET ACQUAINTED

Select a marine mammal.

Draw the marine mammal's face in the space below. (Dolphins, walruses, manatees, seals or whales may be good examples.)

Now draw a series showing how some of these marine animals swim or move, such as a surfacing whale, diving walrus, or a jumping dolphin.

Make the drawings cartoon-style (in the sequence below) so you can visualize the movement. Don't forget to add in the natural marine environment around the animal.

NAME THE ANIMAL

Read each paragraph and see if you can identify the marine organism.

I am a bizarre creature with the arching neck and head of a stallion, the swelling bosom of a pouter pigeon, the grasping tail of a monkey and the color changing power of a chameleon. My eyes pivot independently so that while one scans the surface the other can look underwater. I have a kangaroo-style pouch. At the end of our elaborate mating dance my bride gives me 250 to 300 brick-red eggs. I carry these in my brood pouch for about 45 days and, when the babies are ready to be born, I eject them. Can you name me?

I move by using a water-vascular. I have tiny suction tube feet in each of my appendages. Using these I can creep through the water. I cannot see but the tip of my arms tap, reach and feel. They substitute for vision. When I come to a bivalve (clams, mussels) which I love, I creep on top of them. I wrap my arms around its shell and apply my tube feet with suction tightness to its shell and pull. Eventually the shell opens and I extrude my stomach through my mouth into the body of the clam. The digestive juices of my stomach slowly digest its body. Then I withdraw my stomach back through my mouth and slowly move on. Who am I?

I am a misrepresented animal. I have come to stand for horror and evil. The real truth is that I am afraid of anything larger than I am. Most of us grow no larger than 3 feet across. To avoid enemies, I am a night prowler; during the day I hide. Getting enough to eat is a daily preoccupation with me. Fish are usually too fast for me so I eat crabs and other small shellfish. I dissect them with my parrotlike beak. My eyes are as highly developed as yours and I have the best functioning brain of all the invertebrates. Your scientists study my brain to learn how your brain works. I can be easily tamed and trained to take food from your hand. Who am I?

People are always watching me at the beach soaring and gliding. I spend much of my time preening my feathers. This is not idle vanity. Preening not only keeps me afloat in water but also keeps me aloft in the air. For example to perfect my takeoffs, I preen the top wing covers into a smooth frictionless airfoil. All this helps account for my success on wings. I can fly 35 to 50 miles an hour and travel over 700 miles in 24 hours. When I soar I am not always searching for food, I may just be having fun. I take advantage of the wind currents. I also love the lower, weaker air currents that form from about 3 feet above the waves. I can ride them for hours. Most people think I ride behind boats for food but I also follow them for the thermal currents the ships create at sea. I am a social bird and cannot be alone away from others of my kind. Who am I?

SPECIALLY DESIGNED

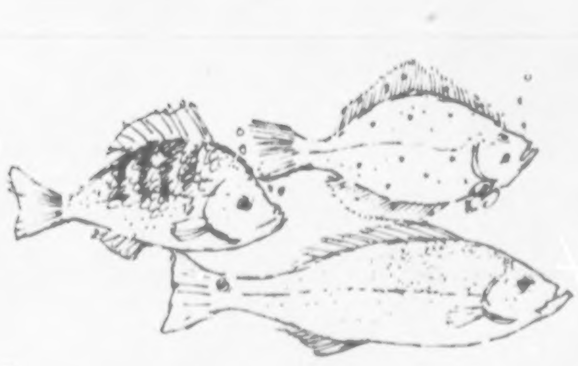
Life in the sea is so ancient that an almost infinite variety of designs, shapes, colors and behavior patterns have developed. All this allows each organism to survive and reproduce.

Fish come in many sizes, colors and shapes. Where the fish lives, how it gets its food, what it eats, how fast it swims and how it interacts with other organisms may all be determined by its body shape. The butterflyfish and spadefish are more laterally flattened than most other fish. This allows them to keep their swimming speed and fit into narrow crevices for food or protection. The sea bass comes in a torpedo shape and can move at express train speed. The pipefish who live in eel grass and manotee grass match the plants with their long, drawn-out and cyclindrical shapes. The rays and skates have a flattened form which is adapted for life on the ocean floor.

Fins are to fish what arms and legs are to men - actually more. Fins have been adapted for many purposes, but they are used mainly for propulsion, stability, steering and braking. The moon-shaped tail of the tuna is designed for high-speed propulsion. The broad tail of a grouper gives it the ability to accelerate very quickly.

Sharks are designed for speed but they have difficulty stopping. Since they can not brake very well, they must make sharp turns. Because of this few sharks go into coral reefs where they would be unable to turn. Instead sharks roam around the reefs.

No matter how strange the design, color or behavior of a marine organism appears, it is designed that way for a purpose to survive in its environment.



DESIGN A BEAK

All organisms have adaptations that allow them to survive and reproduce in their particular habitats. Some of these adaptations enable them to capture and eat their prey.

You are to design beaks of birds that can catch and pick up prey.

1. This bird feeds largely on oysters, clams, marine worms. Design a beak that can act as a knife, goes between the shell, cuts the adductor muscle (which keeps the shell closed) and breaks open the shell.

2. This bird feeds on small mollusca (Donax) crustacea and insect larva found in the sand. Design a beak for probing in the sand for its food.

3. This bird swims completely underwater to catch slow-moving fish. Design a beak so the bird can cock its neck back, spear the fish out of the water and swallow it.

4. This bird eats small insects in the water. Design a beak which can be swung from side to side through the water to capture small insects.

5. Design a beak for a bird that feeds by running along shorelines and snapping up small aquatic invertebrates.

GYOTAKU: PRESERVE IT WITH A PRINT

How can you preserve the memory of the Big One? For many kinds of fish, the answer lies in a Japanese art form called gyotaku, fish printing. Gyotaku is widely practiced by ichthyologists, who find that this method preserves intact all the intricate details by which fish are identified.

Making fish prints is a highly developed art but the basic techniques can be easily learned. The materials that are needed are: India ink, paint brushes (No. 8 or 1/2 inch size) and a fairly absorbent type of thin paper (paper towels or newsprint).

The fish used for the first effort should be a somewhat flattened one. Any kind of fish will work, but "thicker" fish are more difficult to print successfully.

How to Do It

1. Take a preserved or fresh dead fish, rinse it off and blot it dry. (Soap and water may help remove the mucus.) Place it on a sheet of dry newspaper or paper toweling.

2. Record on a sketch where various colors are located on the fish. Color can be added to a finished print with finger paints.

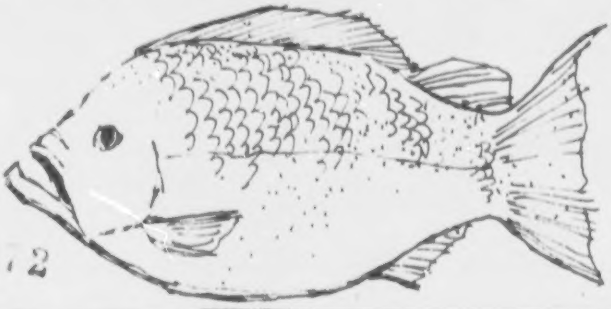
3. If you want the fins to appear erect on the print you should spread the fins and hold them in position by sticking pins through the fins into a piece of clay on the reverse side.

4. Brush ink onto the speciman from front to back, including all fins. Use a heavier coating on the edges of the fish and less on the center. Paint around the eye not over it.

5. Cover the fish with the paper on which the print is to be made. Press evenly with fingers over the entire surface, emphasizing the outline.

6. Peel the print off carefully from head to tail. Add a dot for the eye and add any needed colors or markings

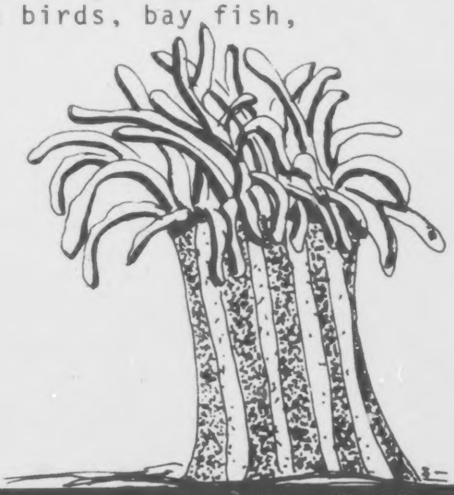
Tempra paint thickened with Ivory Flakes to the consistency of cake batter can be used in place of India ink. The print can also be done on fabric, such as old sheets, unbleached muslin, etc.



MARINE MOBILES

You will need the following materials to make a mobile: thread, fishing line or dental floss, supports--dowels, coat hanger wire or heavy wire, pieces of driftwood, variety of shells or organisms, hammer and small nail or electric drill with small bit, glue.

1. Use the drill or hammer and nail to make a hole in each of the shells. If the hammer and small nail is used, the easiest way to make a hole is to very carefully hammer the nail into the shell from the outside of the shell to the inside. You may use pictures of marine organisms glued on heavy paper, etc. If you are using other marine organisms or ones made of other materials make sure they have a hole so you can thread it, and attach it to the support.
2. Cut a support to the desired length and suspend the threaded shell or object from the end of it.
3. Balance the support by tying another threaded shell or object to the opposite end of the support. To get the support to balance you will need to attach the support from a hook or nail so it can hang freely as it will in the finished mobile. Getting the support to balance may take a little time and effort. If it doesn't get balanced at first move one threaded object closer to the center of the support, shorten the thread or use a lighter or heavier object.
4. Continue to add supports and objects.
5. After the mobile is completed and evenly balanced, apply a drop of glue to each knot to prevent it from slipping of the support and causing the mobile to become unbalanced. You make all types of mobiles. Some of the possibilities are:
   - a) One organism to show variation within a species (shells, etc.)
   - b) Organisms found in a particular ecosystem (jetties, beach, mudflats, etc.)
   - c) Organisms found in particular phylum
   - d) Organisms in a particular grouping--mammals of the sea, birds of the sea, shore birds, bay fish, deep sea fish
   - e) Show various food chains
   - f) Show food pyramids
   - g) etc.



TOPIC SEVEN
EVERYONE BELONGS (ENERGY RELATIONSHIPS)

ACTIVITY ONE--Producer, Consumer...
ACTIVITY TWO--Who's For Dinner?
ACTIVITY THREE--Who-Eats-Whom (Food Chain)
ACTIVITY FOUR--Can Life Exist Without Light?
ACTIVITY FIVE--The Big Web
ACTIVITY SIX--It's a Pyramid!

Materials for Classroom Use:

Producer, Consumer.../reading
*Marine Organism/card deck
*Who's For Dinner?/instructions
Who-Eats-Whom Chain/reading
*Who-Eats-Whom/instructions
Sketches of the marine ecosystems from Topic Six
The Rocky Shore
Sandy Beach
Mud Flat
Salt Marsh
Oyster Reef
Water, Itself (Life on Continental Shelf)
Can Life Exist Without Light?/reading
What Would Happen If....?/activity
The Uninvited Guest/reading
Food Pyramid/reading
It's a Pyramid/sketch
Make a Dolphin/instructions
Make a Dolphin/game board and cards
Food Pyramid/questions
Managing a Small Bay/activity
Food Web of Bay/sketch
Scissors
Glue
Heavy paper

---

*Idea from PREDATOR the food chain game
Ampersand Press
2603 Grove Street
Oakland, Ca. 94612

Major Objectives for the Topic

After completing the topic the student will be able to:

1.1 if given an ecosystem, point out the producers, consumers and decomposers:
1.1 define and give examples of producers, consumers, decomposers, herbivores, carnivores and omnivores;
1.1 define food chain, food web and food pyramid;
1.1 classify organisms into categories of herbivores, carnivores and omnivores;

1.3 construct model food chains;
1.3 diagram the energy flow from the sun to man;
1.3 conclude that the food chain is the transfer of energy from the source in plants through a series of organisms repeatedly eating and being eaten;
1.3 compare and contrast land and marine food chains;
1.3 make inferences as to what would happen to the food web if all plants were destroyed;
1.3 make inferences as to what would happen if certain animals in the food web were killed;
1.3 interpret what happens to the mass (nutrients) and energy as one moves up the food pyramid.
1.3 conclude that not only is energy being transferred in a food web or food pyramid but so are a host of nutrients, and although there is a progressive decrease of energy in this trophic or feeding chain, the nutrients are not diminished;
1.3 identify what group of organisms the food pyramid indicated as being the least numerous and the most numerous;
1.3 explain and diagram a food chain, food web and food pyramid;
1.3 recognize that ecological relationships are energy-oriented with radiant energy (sunlight) being the source and this energy is transformed from the radiant to the chemical form in photosynthesis and from the chemical to the mechanical and heat forms in cellular metabolism (in organisms);
1.3 justify why light is the most fundamental abiotic factor in an ecosystem;
1.3 predict the effects of the increase or decrease of the number of organisms in one level of the food pyramid;
1.3 explain what is being transferred between all organisms in a food chain, food web and food pyramid;
1.3 using the food pyramid justify why it is often larger birds that will die from DDT which washed into the sea;
1.3 using the food pyramid again relate the advantages and disadvantages of man eating plants versus eating high animals;
1.3 describe possible future marine food chains, food webs, and food pyramids;
2.1 point out ways that man does affect the food chains and webs;
4.3 evaluate the purpose and role of each organism in the ecosystem.

Teaching Suggestions:

The purpose of this lesson is to present information to the student and help him understand the energy and nutrient flow (food chains, pyramids, webs) within a marine ecosystem.

1. Have the students complete the readings and respond to the questions and activities.

2. Have the students meet in small groups to discuss the questions and/or cooperatively work on activities.

3. Reproduce the materials for the games on index card stock or on a lighter paper which can then be glued on posterboard or cardboard and laminated. If you prefer to purchase additional sets of the marine organism cards printed on heavier paper write to:

Marine Information Service
Sea Grant College Program
Texas A&M University
College Station, TX 77843

The marine organism cards can be used in numerous ways other than for the activities mentioned. You can use them in classification and adjust the rules of most card games to be used with the cards.

4. Play the Who's for Dinner? game before discussing food chains. During the playing of the game some students will figure out that certain cards (those higher in the food chain) are less likely to be eaten. After the game you can use the student experiences with the game as a basis for your discussion of food chains. You then may want to play the game again. Set a time length for the game because it can continue forever, like the food chain. Allow at least 25 minutes for the first playing of the game since it will take the students a few minutes to become acquainted with the rules.

5. You can again use the cards to build food chains in Who-Eats-Whom. (The playing of it is similar to straight dominoes.) You may vary the instructions if you desire.

6. Can Life Exist Without Light? is based on the recent discoveries. Additional information is found in National Geographic Vol. 154, no. 3, (Sept. 1978) "Undersea Wonders of the Galapagos" pp. 362-381. Discuss the implications of these findings to our present knowledge and possible uses of this in mariculture.

7. You may want to do the "What Would Happen If....? activity outside. You may want to have your students suggest possible actions and then determine their effects on the food web.

8. Food Web Tag must be played outside or in a gym. After the first playing, the students may suggest changes such as a certain number for each of the organisms -- more plankton, one porpoise, etc. They may want to try to set a balanced food web.

9. Make a Dolphin game is an excellent way for the students to develop an understanding of the numbers of organisms and the energy involved. Have the students make an arrow for the spinner for the Dolphin game from index card stock or heavy material. Use a brass fastener to attach the arrow to the spinner board of the Dolphin game. Grouping the students will reduce the number of copies and materials required and will lend itself to good interaction.

10. Have the students answer the food pyramid questions individually or as a group, then discuss them as a class. Encourage students to generate related questions and then strive to answer them cooperatively.

11. Managing a Small Bay Area/activity is a summary activity in which

students can use the knowledge they have of food chains, pyramids and webs and apply it to a management situation. Discuss all the possible results and implications.

12. The references cited at the end of the teacher section of Topic Six will be helpful in this section.

TOPIC SEVEN
EVERYONE BELONGS (ENERGY RELATIONSHIPS)

PRODUCER, CONSUMER...

Read--

Producer, Consummer...

Separate--

The marine organism card deck into three groups: producers, consumers and decomposers.

Divide--

A sheet of paper into three columns. Label the columns: producer, consumer, decomposer. In each column list some organisms that belong in the column.

Separate--

The marine organism card deck into three groups: herbivores, carnivores, ominivores.

Look at--

Your sheet with the columns of producers, consumers and decomposers.

Place--

The letter H by all herbivores, the letter C by all carnivores and the letter O by all ominivores on your sheet.

Answer--

1. Is man a producer or consumer? Explain.
2. To which group, herbivores, carnivores or ominivores does man belong? Why?

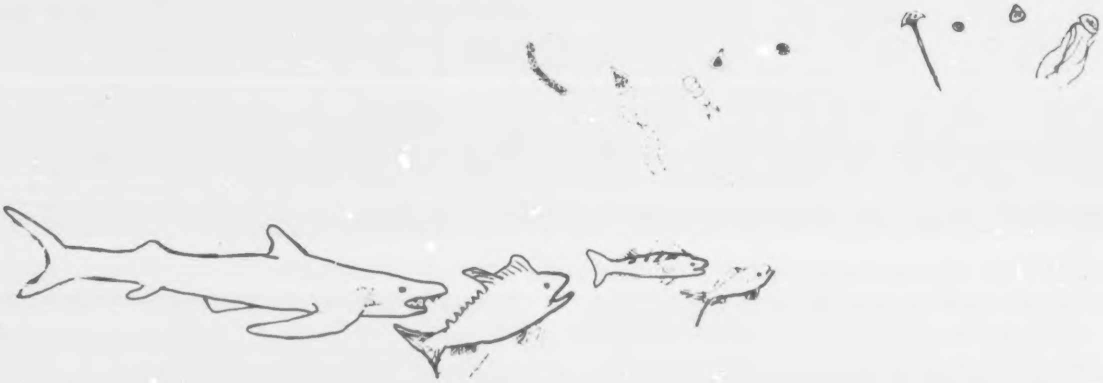
PRODUCER, CONSUMER ....

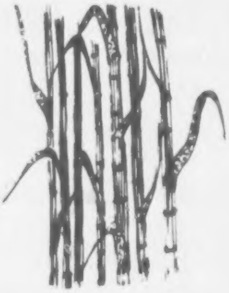
For life to exist and reproduce in an ecosystem, four components must be present: (1) producers, (2) consumers, (3) decomposers and (4) non-living substances. Every living organism is either a producer, consumer or decomposer, depending on how they get their food.

A producer is an organism that produces its own food from raw materials. The raw materials are the sun's energy, carbon, oxygen and other chemicals. Green plants are the world's producers.

Organisms must feed on materials that already exist. They cannot make their own food. There are three kind of consumers, plant eaters (herbivores), flesh eaters (carnivores), and plant and flesh eaters (omnivores). Plant eaters are called primary (first) consumers. Flesh eaters are called secondary consumers. Secondary consumers are eaten by other consumers.

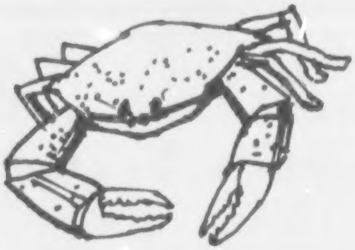
Organisms which feed on the dead are decomposers. They break down organisms into simple materials, the non-living materials. These are the materials that the plant uses to make its food. Bacteria and fungi are the best known decomposers. From non-living materials used by a producer to composer, to decomposer, the materials of life go in a full cycle.





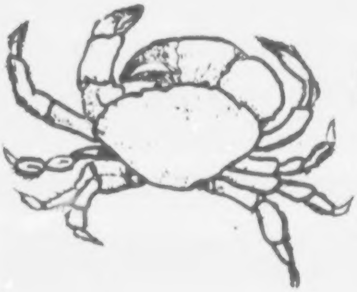
**grass
(cordgrass)**

EATS:	*EATEN BY:*
plants make their own food	plant eating insects; crabs mice, rabbits



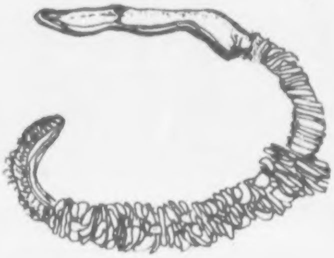
**crabs
filter feeders
(porcelain)**

EATS:	*EATEN BY:*
phytoplankton zooplankton detritus	shorebirds, swimming and diving birds, wading birds, crabs, turtle, flounder, fish-drums, trout, ray, otter



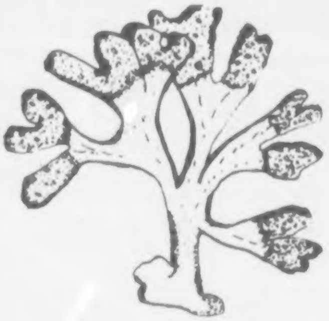
**crabs
(stone, calappa)**

EATS:	*EATEN BY:*
oysters barnacles other crabs clams gastropods	crabs, ray fish-drums, redfish, otter, croaker, trout, flounder, turtle wading birds, shorebirds, swimming and diving birds



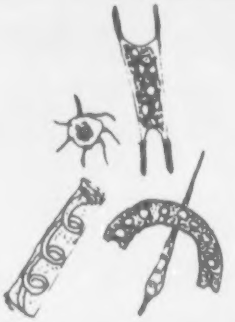
**marine worms
(tubebuilding
worms, parchment, scale
worms)**

EATS:	*EATEN BY:*
detritus zooplankton algae detritus phytoplankton	shorebirds mollusk-murex turtle shrimp



algae

EATS:	*EATEN BY:*
plants make their own food	marine worms, gastropods, fish, mollusks, waterfowl, filter feeders, deposit feeders



phytoplankton (diatoms)

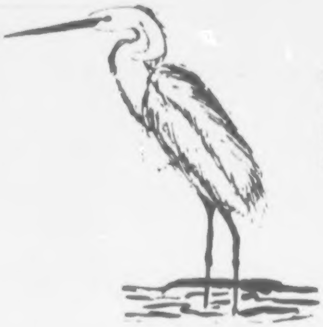
EATS:	*EATEN BY:*
plants make their own food	permanent zooplankton, temporary zooplankton, barnacles, marine worms, mollusks, crabs

whale (pilot)

EATS:	*EATEN BY:*
fish-mullet, drum, croakers, trout squid	

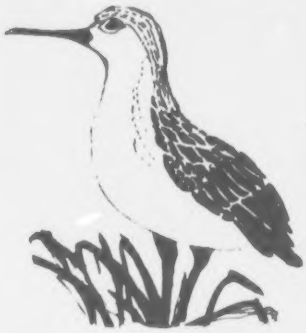
grass (widgeon grass) (turtle grass)

EATS:	*EATEN BY:*
plants make their own food	plant eating insects; crabs, mice, rabbits



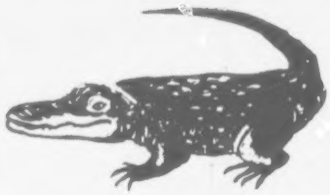
wading birds (heron, egret, ibis, cranes, spoonbill)

EATS:	*EATEN BY:*
shrimp	alligator
crabs	
fish	



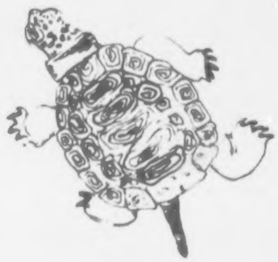
shorebirds (gulls, terns, sandpipers, plovers, turnstones, surfbirds plalaropes)

EATS:	*EATEN BY:*
marine worms	hawks, alligator, mink
pelecypods	
shrimp	
crabs	
insects	
fish	



alligator

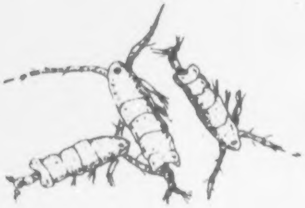
EATS:	*EATEN BY:*
fish	
blue crabs	
raccoon	
muskrat	
birds	
turtle	



turtle

diamond back

EATS:	*EATEN BY:*
grasses	alligator
mollusks	
insects	
crabs	
worms	



permanent zooplankton
small crustaceans

EATS:

phytoplankton

EATEN BY:

temporary zooplankton, barnacles, mollusks
fish-mullet
oyster, sea perch

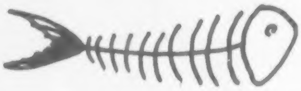
plant-eating insects (grasshoppers)

EATS:

grasses

EATEN BY:

turtle, flying birds, seaside sparrow, shorebirds

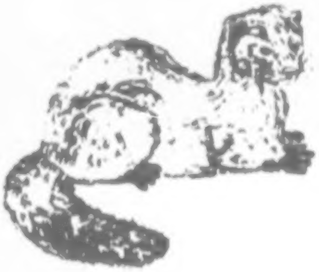


death & decay

EATS:

EATEN BY:

fiddler crabs, plant-eating insects, turtles
mice, tiger beetles



mink

EATS:

fish
clams
mussels
mice
muskrats
birds

EATEN BY:

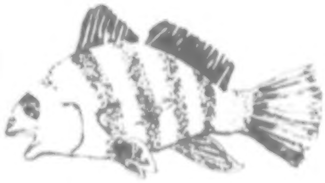
alligator
hawk

swamp rabbits

EATS:	*EATEN BY:*
grasses	alligator hawk

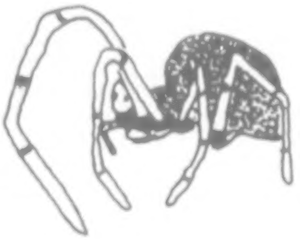
river otter

EATS:	*EATEN BY:*
fish crabs	alligator



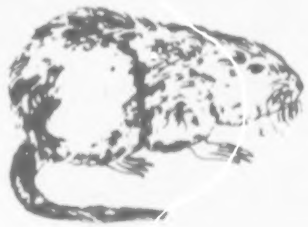
fish—
(drums, redfish,
croakers, trout)

EATS:	*EATEN BY:*
shrimp crabs mullet perch mollusks	fish, dolphin, whale, otter



spiders

EATS:	*EATEN BY:*
plant-eating insects	flying birds, mice, seaside sparrow, shorebirds



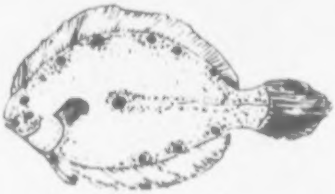
muskrat

EATS:

plants

EATEN BY:

hawk, mink, alligator



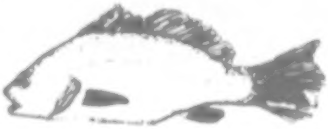
fish—flounder

EATS:

squid
shrimp
crabs
small fish

EATEN BY:

fish, shorebirds
dolphin, whale,
wading birds



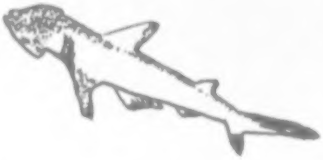
fish—redfish, snappers, jackfish

EATS:

shrimp
squid
crabs
mullet
perch
small fish

EATEN BY:

fish, dolphin, whale, otter, wading birds, shorebirds, swimming and diving birds



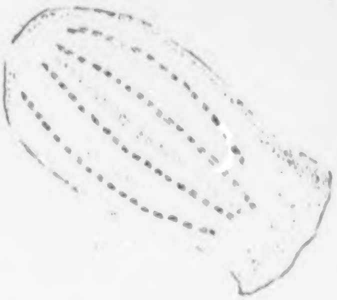
shark (shovel-nosed sand shark)

EATS:

crabs
shrimp
fish

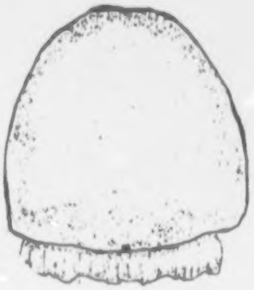
EATEN BY:

other sharks



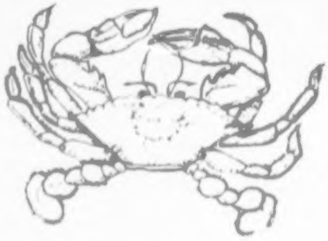
ctenophores (phosphorous jelly, sea walnut)

EATS:	*EATEN BY:*
temporary zooplankton	jellyfish fish



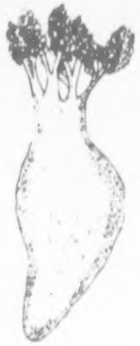
jellyfish

EATS:	*EATEN BY:*
filter feeders, temporary zooplankton, ctenophores	crabs



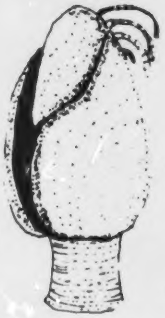
crabs—(blue, fiddler)

EATS:	*EATEN BY:*
detritus grass shrimp fish crab	turtles, seaside sparrow, fish-drum, red snapper trout, redfish, otter, ray, sharks, flounder, wading birds, other crabs, shorebirds



sea cucumbers

EATS:	*EATEN BY:*
detritus plankton algae	sea snails melanella



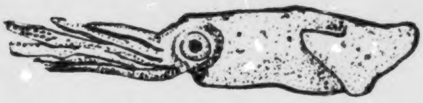
barnacles

EATS:

permanent
& temporary
plankton,
phytoplankton

EATEN BY:

mollusk
drill, whelk,
stone crab



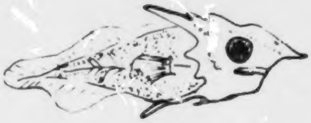
squid

EATS:

small fish
shrimp

EATEN BY:

flounder
whale



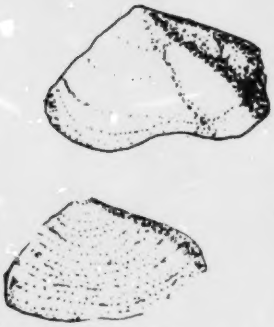
permanent zooplankton (protozoans)

EATS:

phytoplankton

EATEN BY:

temporary zooplankton
phytoplankton
sea anemone
sea cucumber
marine worm
barnacle
mollusk
crab
oyster
certain fish



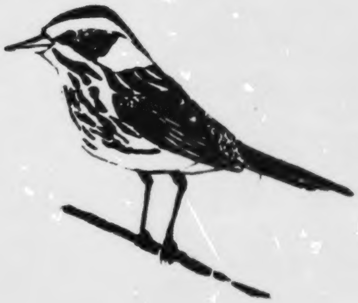
mollusk—pelecypod deposit feeders (macomas, clams, tellins)

EATS:

detritus
algae

EATEN BY:

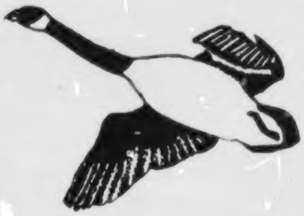
shorebirds, fish,
swimming and
diving birds,



bird (seaside sparrow)

EATS:
insects
crabs

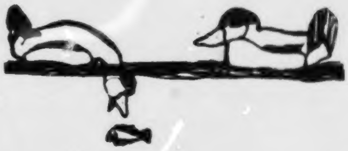
EATEN BY:



waterfowl (surface feeding ducks, teal, geese, swans)

EATS:
plants
detritus

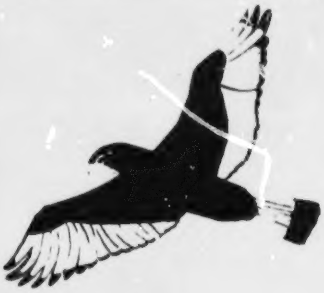
EATEN BY:
hawks, mink,
alligator



swimming and diving birds (sea ducks, stifftails, grebe, comorants)

EATS:
shrimp
crabs
mollusks
fish

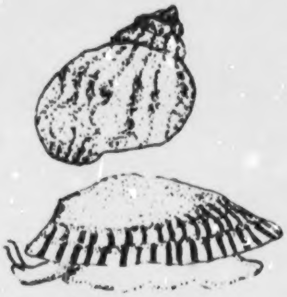
EATEN BY:
hawks, mink,
alligator



flying birds hawks

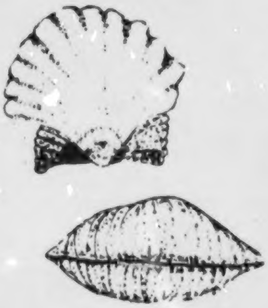
EATS:
plant-eating
insects
birds
rabbits
mice
mink
muskrat

EATEN BY:



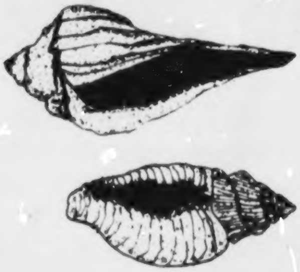
mollusks—gastropods (sea snails melanella)

EATS:	*EATEN BY:*
Portuguese-man-of-war, jellyfish sea cucumbers sea anemones	fish, swimming and diving birds



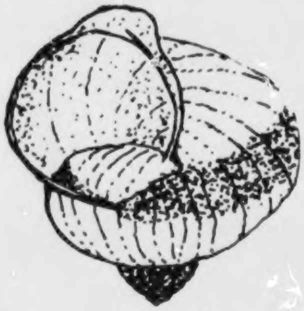
mollusk-gastropods, filter feeders (limpets, periwinkies, tegula slipper shell)

EATS:	*EATEN BY:*
algae grass phytoplankton zooplankton	ray, turtle, saltwater perch, drum, redfish, trout



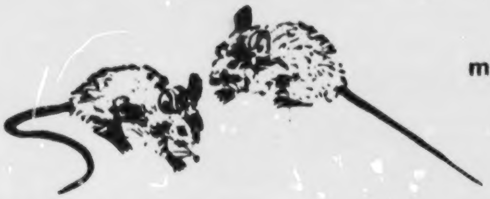
mollusks—gastropods (moon shell bonnet, drill, conch, whelk, murex)

EATS:	*EATEN BY:*
oysters clams mussels other bivalves worms barnacles	ray fish, turtles stone crabs, shorebirds, swimming and diving birds



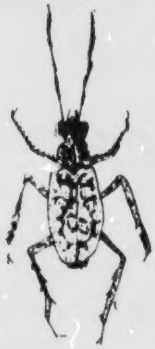
mollusks—pelecypods filter feeders (bivalves, clams mussels, scallops cockles, donax)

EATS:	*EATEN BY:*
algae plankton detritus	moon shell, mink, turtle, drill, whelk, crabs, drum-fish, shorebirds, s & d birds



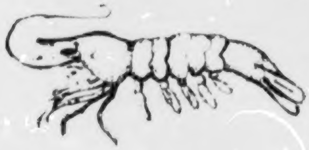
mice

EATS:	*EATEN BY:*
grasses plant-eating insects, spiders detritus	hawks, minks, muskrats



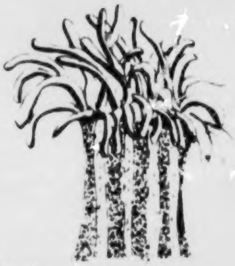
insects (tiger beetles)

EATS:	*EATEN BY:*
detritus	birds mice



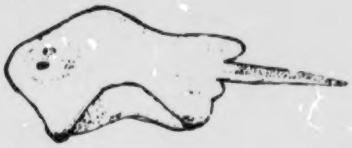
shrimp

EATS:	*EATEN BY:*
algae small clams marine worms temporary zooplankton small fish other shrimp	squid, wading birds, shore-birds, diving and swimming birds, seaside sparrow, ray, saltwater perch, shark fish-drum, red-fish, trout



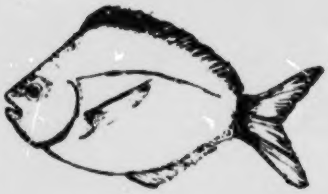
sea anemones

EATS:	*EATEN BY:*
small fish zooplankton (permanent & temporary)	sea snails melanella



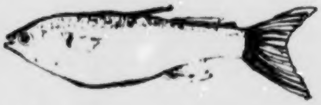
ray (stingaree)

EATS:	*EATEN BY:*
marine worms mollusks shrimp crabs plant material detritus	



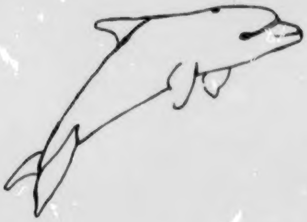
fish—saltwater perch or pinfish

EATS:	*EATEN BY:*
algae plankton small shrimp crabs mollusks	otter, redfish, dolphin, whale, redfish, snappers alligator, jackfish, wading birds, swimming and diving birds, shorebirds



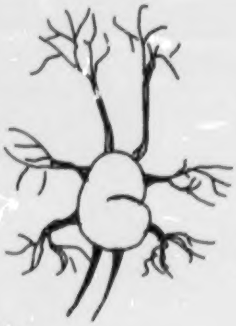
fish-mullet

EATS:	*EATEN BY:*
detritus plankton	dolphin, otter, wading birds, shorebirds, swimming and diving birds, whale, fish-jack fish, drum, croakers, trout redfish, snapper



dolphin (bottle-nosed dolphin)

EATS:	*EATEN BY:*
fish-mullet drum, croaker, trout flounder	



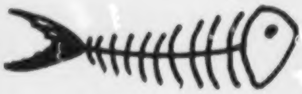
temporary zooplankton (larva of shrimp, oysters, mollusks, crab)

EATS:

phytoplankton
permanent
zooplankton

EATEN BY:

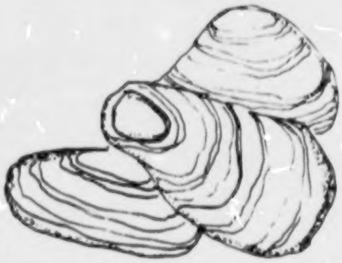
ctenophores
jelly fish
filter feeders
barnacle
mollusk
sea anemone
sea cucumber
marine worm
crab
certain fish



death & decay

EATEN BY:

fiddler crabs, plant-eating insects, turtles mice, tiger beetles



mollusk—pelecypod (oyster)

EATS:

detritus
diatoms
phytoplankton
zooplankton

EATEN BY:

drill, conch,
crabs-stone blue
fish-drum
shorebirds
swimming and
diving birds

detritus (disintegrated plant and animal material)

EATEN BY:

crab-filter feeders, waterfowl, mice, mollusk, fiddler crab, blue crab, tiger beetle, marine worms

TOPIC SEVEN
EVERYONE BELONGS (ENERGY RELATIONSHIPS)

WHO'S FOR DINNER?

Play--

Who's for Dinner? game using marine organism card deck.

Answer--

Questions.

WHO'S FOR DINNER ?

(Card game)

1. Use the deck of marine organism cards.

2. As life in the salt marshes and bays goes on and on, so does this game. 15 to 30 minutes should be adequate.

3. Two to six players are best. More may play.

4. Deal all cards out. Some students may get more than others.

5. Person to the left of dealer starts play by asking any individual for a showdown.

6. At the same time, each of the two players lays down one of his cards. If one card "eats" another, that player takes the "eaten" card. If neither eats the other, it is a standoff, and each returns his card to his hand. Play goes on to the next person. If both cards "eat" each other, it is also a standoff.

7. When a player's turn comes and he knows where a certain card is that he can take with one of his cards, then he can challenge rather than ask for a showdown.

8. In a challenge, the player demands a certain card and shows the card with which he can take it. (Sally, I want your GRASS card, and I'm taking it with my PLANT EATING INSECT card.) He then wins the card and is entitled to another turn. As long as he can win cards in a challenge, he is entitled to another turn. (This is not so in showdown, even if someone wins.)

9. If the challenger was wrong and the person he challenged did not have that card, he must give up his challenging card to the person wrongly challenged and his turn is over.

10. When a challenger is no longer sure where the cards are that he can take, he should ask someone for a showdown, and this ends his turn.

11. Sometimes, two kinds of animals can eat each other. For instance, fish eat each other. In a showdown, neither takes the other. But in a challenge, the challenger does take the other card.

12. No cards are laid down, they are all kept in the hand. No player may use the same card consecutively.

13. The two Death and Decay cards are very powerful. Their use is restricted: (a) Death and Decay may be used as a challenging card only once in a person's turn. (b) There are organisms that can take Death and Decay cards: anything that consumes decaying or decayed material. In

a showdown, they provide a standoff with Death and Decay. In a challenge, the challenger wins. A person may capture only one Death and Decay card by challenge in any one turn.

14. As players become familiar with cards and game, it may be necessary to restrict a player's time to one minute. That is, a player must challenge or ask for a showdown within one minute of his turn. Select a timer, someone who is not playing.

15. When the time set for the length of the game expires, the player with the most cards wins.

Answer:

1. When one organism eats another, what is actually passed from one organism to another?

2. What would all plants need to live?

3. If you want to avoid being eaten which organism would you like to be or at what position in the food chain?

TOPIC SEVEN
EVERYONE BELONGS (ENERGY RELATIONSHIPS)

WHO-EATS-WHOM (FOOD CHAIN)

Read--
Who-Eats-Whom (Food Chain).

Play--
Who-Eats-Whom using the marine organism card deck.

Answer--
Questions.

Build--
Four different food chains.

Share--
The chains you have built with your classmates.

Answer--
Questions on what would happen to the food chain under different circumstances.

Look at--
Sketches of the marine ecosystems in Topic Six.

Draw--
As many food chains as you can see in the sketches.

Share--
The chains that you have found with your classmates.

Read and discuss--
Can Life Exist Without Light?

Draw--
Food chains based on the above reading.

Make--
Mobiles of the food chains in the different marine ecosystems. Use sketches of the organisms, string and coat hangers.

WHO--EATS--WHOM

(Food Chain)

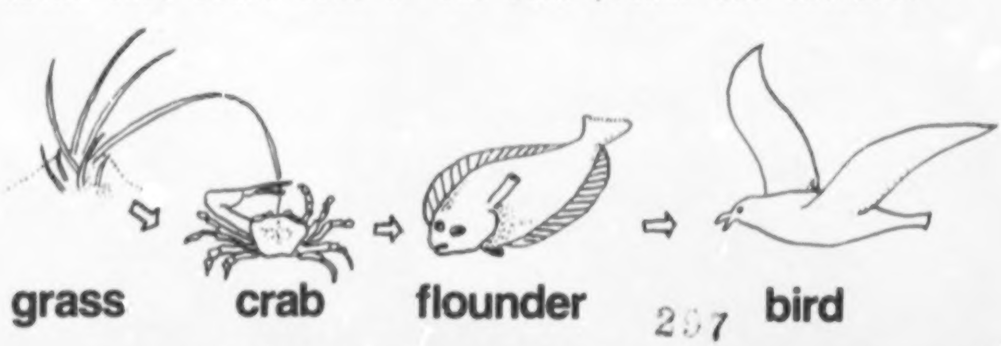
All food can be traced back to green plants. Without green plants nothing else can live. It is only the green plants that can capture energy from the sun and together with water, air, and soil change them into the chemical energy of foods. The green plants produce the foods that keep the ecosystem running. No other form of life can do this.

All other living things depend directly or indirectly upon plants for food. You can picture this as a sequence of "who--eats--whom," or a chain within an ecosystem. In nature everybody seems to be food for some other creature. Plant eaters or herbivores eat plants. A herbivore is a first order consumer. They are then eaten by meat eaters (carnivores). A carnivore who eats a herbivore is a second order consumer. Carnivores are eaten by other carnivores. A carnivore who eats another carnivore is a third order consumer. Those carnivores are eaten by still other carnivores. In this way we get a food or energy chain that may have four or five links.

A four link chain may take place if grass is eaten by a fiddler crab, a fish-flounder eats the crab and a wading bird eats the flounder. If the wading bird were eaten by an alligator then the chain would be made of five links.

All food chains end when the dead organisms or the waste products of living things are eaten by fungi, bacteria and other agents of decay. These are the decomposers. They use the last energy left in the materials and break them back down to their basic elements. These basic elements, carbon and nitrogen, are returned to the air, soil and water. These elements are then used by the green plants to begin the cycle again. All food chains begin and end with water, soil and air, so all complete food chains begin and end with the basic elements that are used over and over again.

Plants are usually eaten by more than one kind of animal. A herbivore often eats more than one kind of plant. A carnivore usually eats more than one kind of animal. This more complicated pattern of "who--eats--whom" can be shown as a food web. A food web is a combination of two or more food chains that share some of the same plants and animals.



WHO EATS WHOM
(Card game)

1. Use the deck of marine organism cards.
2. Two or six may play.
3. Choose for dealer and score keeper. Mix the cards.
4. The dealer places the first card from the deck face down on the center of the table.
5. The cards are then dealt to the players until each player has seven cards in his hand.
6. The remaining cards in the deck are placed on the table.
7. The card in the center of the table is placed face up. This card serves as the basis for the food web the players will build.
8. The player to the left of the dealer is first to play. He may build up or down on the basic card. He builds on the basic card what it eats and what eats it.

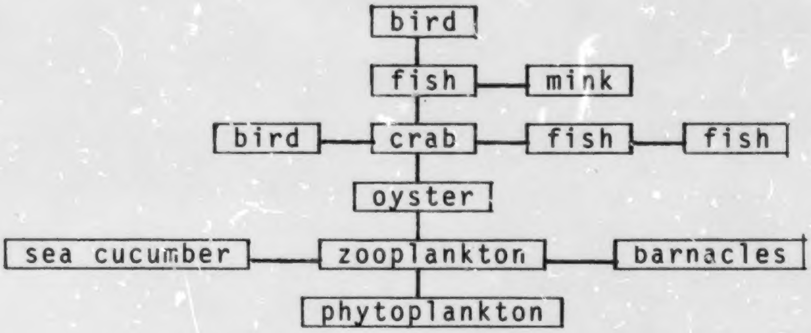
   Example: Basic card
   Oyster

   The player can add zooplankton to the bottom or crab to the top in this case.

   Oyster

   zooplankton

9. After he has played his card it is the turn of the player to his left.
10. Each player adds one card to the food web. If he cannot play when it is his turn, he draws from the deck on the table until he draws one that he can play. If there are no cards left in the deck, he passes.
11. After several rounds the food web may be similar to the example on the next page.


bird
fish
mink
bird
crab
fish
fish
oyster
sea cucumber
zooplankton
barnacles
phytoplankton

12. The first player to play out all the cards in his hand wins the game.

Answer

1. In each food chain, what is the first link?

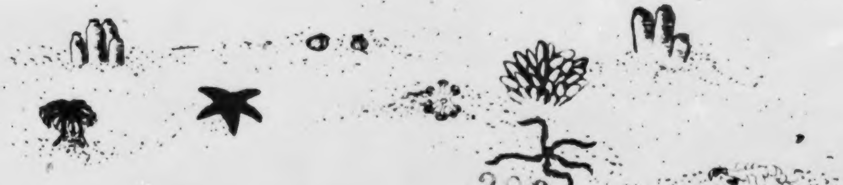
2. Which animals are the first oder consumers?

3. Where does man fit into the food chain?

4. Which animals are second order consumers?

5. Why can we say that not even green plants are independent organisms?

6. Why does a food web represent the food-energy relationships of an ecosystem better than a food chain?



BUILD THE FOOD CHAINS

1. A food or energy chain with 3 links, a producer, a consumer and a decomposer.

2. A food chain with 5 links (using different organisms than in the first chain, if possible).

3. A food chain which has the same start and finish, but the rest is different.

4. A food chain on the ocean floor where no sunlight is present.

Answer

What would happen to the food chain if
(1) there were no nutrients (air, water, soil)?

(2) if the water became too muddy to allow sunlight through?

(3) if the decomposers were killed by chemicals?

(4) if man removed all fish by overfishing?

TOPIC SEVEN
EVERYONE BELONGS (ENERGY RELATIONSHIPS)

CAN LIFE EXIST WITHOUT LIGHT?

Discuss--

The question can life exist without light in the ocean depths?

Build--

A possible food chain that could exist in the depths of the ocean without energy from sunlight. Possible sources of energy could be decaying matter drifting down from the upper regions or chemicals found in the sediments of the ocean floor.

Share--

The food chain you built with your classmates.

Read--

Can Life Exist Without Light?

Build--

A food chain based on the reading "Can Life Exist Without Light?"

Compare--

The two food chains (before and after the reading).

Answer--

1. How does this food chain differ from others you built in other activities?
2. How many different food chains can there be?

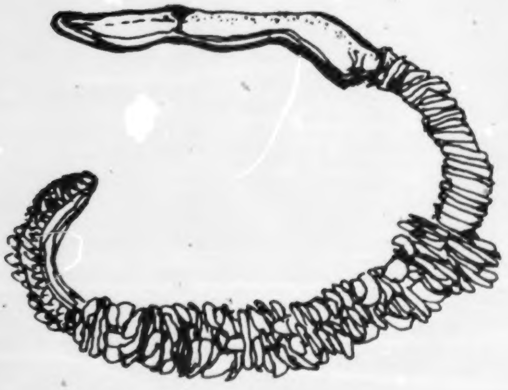
CAN LIFE EXIST WITHOUT LIGHT ?

An oasis of life exists in the depths of the ocean. The animals are part of a food chain that is based on energy from inside the earth rather than from the sun.

In the boundary between the separating plates of ocean crust--lava erupts, cools and cracks. Cold seawater penetrates the fractures where, under the extreme heat and pressure, the sulfate in the seawater is converted to hydrogen sulfide. Certain bacteria use the hydrogen sulfide as a source of energy (food) and multiply. Large organisms, including tube worms and clams, in turn eat the bacteria. So here in total darkness, there is a chain of life which does not need sunlight. The energy souce is chemicals from within the earth This chain depends on chemosynthesis instead of photosynthesis.

A group of scientists exploring hydrothermal vents of the Galapagos Rift west of Ecuador in the submersible Alvin made history for marine biology. They discovered unknown organisms and dense communities of life around the hot water vents of the ocean floor. Around one vent they found hundreds of clams larger than dinner plates (12 to 16 inches) and around another huge tube worms over 18 inches long. At another vent there were crabs eating feather-duster worms and an octopus hunting crab. Each vent appears to have its own fauna. It is possible that the first larva to reach the vent when it becomes active becomes the dominant organism. These organisms live in total darkness and depend on the chemicals of the hot-water vents. If a vent stops releasing hot water, the organisms die.

These questions remain. How many more vents like these exist along the 40,000 mile long system of oceanic rifts? How many of these support life? Their existence will revolutionize our knowledge of life in the dark of the ocean depths.



TOPIC SEVEN
EVERYONE BELONGS (ENERGY RELATIONSHIPS)

THE BIG WEB

Look at--
The sketches of the marine ecosystems in Topic Six.

Draw--
The food web you find in one of the marine ecosystem sketches.

Compare--
The food webs of the different marine ecosystems.

Place--
Arrows or string to show the food webs in your mural of the ocean.

Complete--
What Would Happen If...? activity.

Read--
The Uninvited Guest.

Write--
A statement on "The effect of nutria on a coastal food web."

Optional

Read--
"Nutria Feast" Texas Parks & Wildlife Magazine, Vol. 33, No 2 (Feb. 1975) pp. 20-22.

Describe or Draw--
A possible future food web.

Answer--
1. What substances or actions will affect the future food web?
2. Will future food webs be the same as they are today?

Play--
Food Web Tag. This is played outdoors. Each student draws a marine organism card. He must try to get through the game without being eaten (tagged) and he must get enough to eat (tagging his food). Set a time limit, which could be the end of the day. Those marine organisms (students) who have eaten and have not been eaten are the winners.

WHAT WOULD HAPPEN IF . . . ?

Draw one card from the marine organism deck. Make a card with the organism's name on it. (Large enough so it can be seen.) Tape the name to yourself. Then using string, connect all organisms (represented by your classmates) that interact (eat) with each other. This will give you an idea of why the food-energy relationships in an ecosystem are more like a web than a chain.

Now illustrate the effect of some substances or actions on the food web you and your classmates are representing. You will do this by dropping all the strings you are holding if the organism you represent is killed or affected.

Illustrate the effect of some of the following actions or substances:

(1) A man sprays the edge of a bay or marsh with a herbicide (plant killing spray) to get rid of some unwanted plants.

(2) City X dumped so much sewage into the water that the decomposers used all the oxygen in the water.

(3) A pesticide killed all insects.

(4) There was an overpopulation of crabs.

(5) All the mollusks were killed.

(6) Add man to the food web.

Describe a possible future food web.

1) What substances or actions will affect it?

2) Will future food webs be the same as they are today? Why/why not?

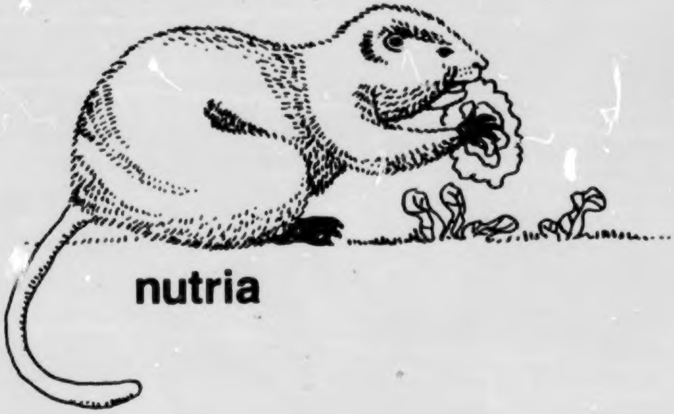
THE UNINVITED GUEST

The nutria is a large rodent, nearly as large as a beaver, but with a long rat-like tail. Its natural range is South America. It prefers to live in swamps, marshes and along the shores of rivers, lakes and coastal estuaries. The nutria are equally at home in salt and fresh water. Its natural food consists almost entirely of aquatic and semi-aquatic plants. When it lives along the coast, it also feeds on shellfish.

In Texas, it has been widely introduced as a "cure-all" for ponds, rivers and lakes choked with vegetation. It does eat many kinds of water plants, but it does not eat algae and many of the submerged plants. The problem is that once the nutria gets established in an area, its efficient reproduction soon leads to overpopulation. Soon there are so many nutria that there are not enough plants to eat. Then the trouble begins. The nutria moves in where it is not wanted and destroys plants that are valuable for waterfowl and muskrats.

In South America, the nutria were important as fur producers. In the United States, the muskrats are well established, and more valuable, fur producing animals. The nutria compete with the muskrats. We face the possibility of having our muskrats being driven out and replaced by the less desirable nutria.

What is the effect of the introduction of an organism like nutria into a food web where it is not naturally a member?



nutria

TOPIC SEVEN
EVERYONE BELONGS (ENERGY RELATIONSHIPS)

IT'S A PYRAMID!

Look at--

Sketch of a food pyramid.

Read--

It's a Pyramid!

Play--

Make a Dolphin.

Answer--

Questions on food pyramids.

Describe--

Possible future food pyramids.

Look at--

Sketches of Bay Food Pyramids.

Complete--

Managing a Small Bay Area.

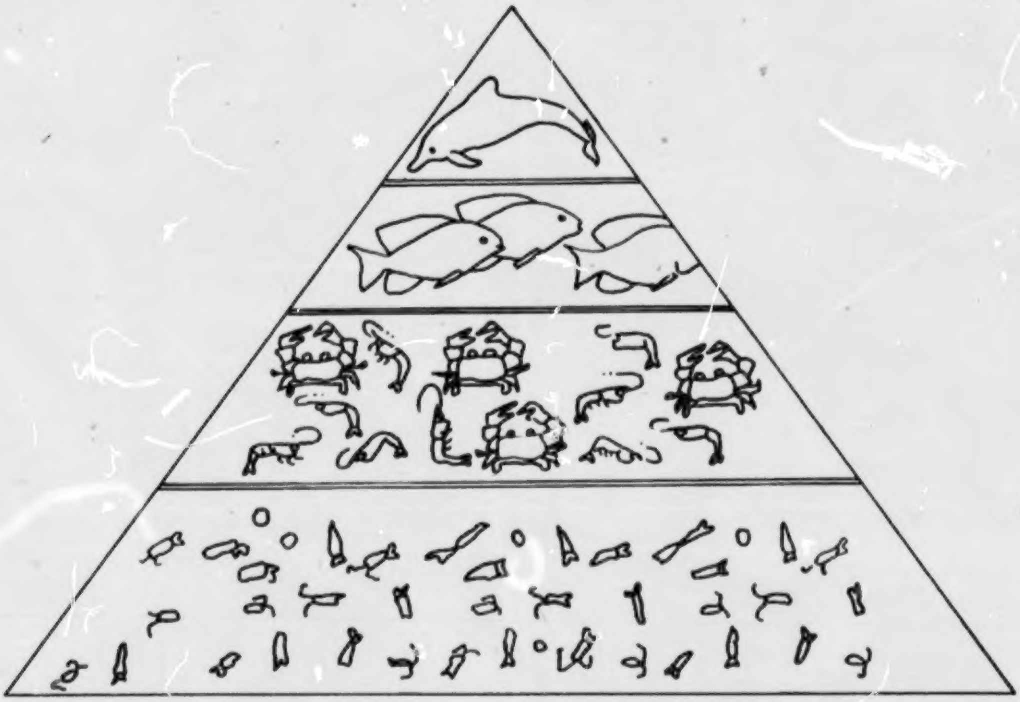
IT'S A PYRAMID

Another way the giving and taking of food among plants and animals can be shown is in a food pyramid. In the food pyramid, each block represents a different organism. A food pyramid can be arranged to show:

1) who eats whom
2) the amounts of food or energy one living thing needs compared to the amounts another living thing needs.
3) the differences in the numbers of organisms involved in each line of the chain.

4) not all the energy is passed from one level to the next. Most is used by the organisms in living so it cannot be passed to the next level. Some energy is lost in being passed on. With each level there is less energy left to pass on to the succeeding level. With each level there also are fewer and fewer members. A food pyramid does show the true feeding patterns of organisms, since many may eat a wide variety of organisms.

THE FOOD PYRAMID



MAKE A DOLPHIN

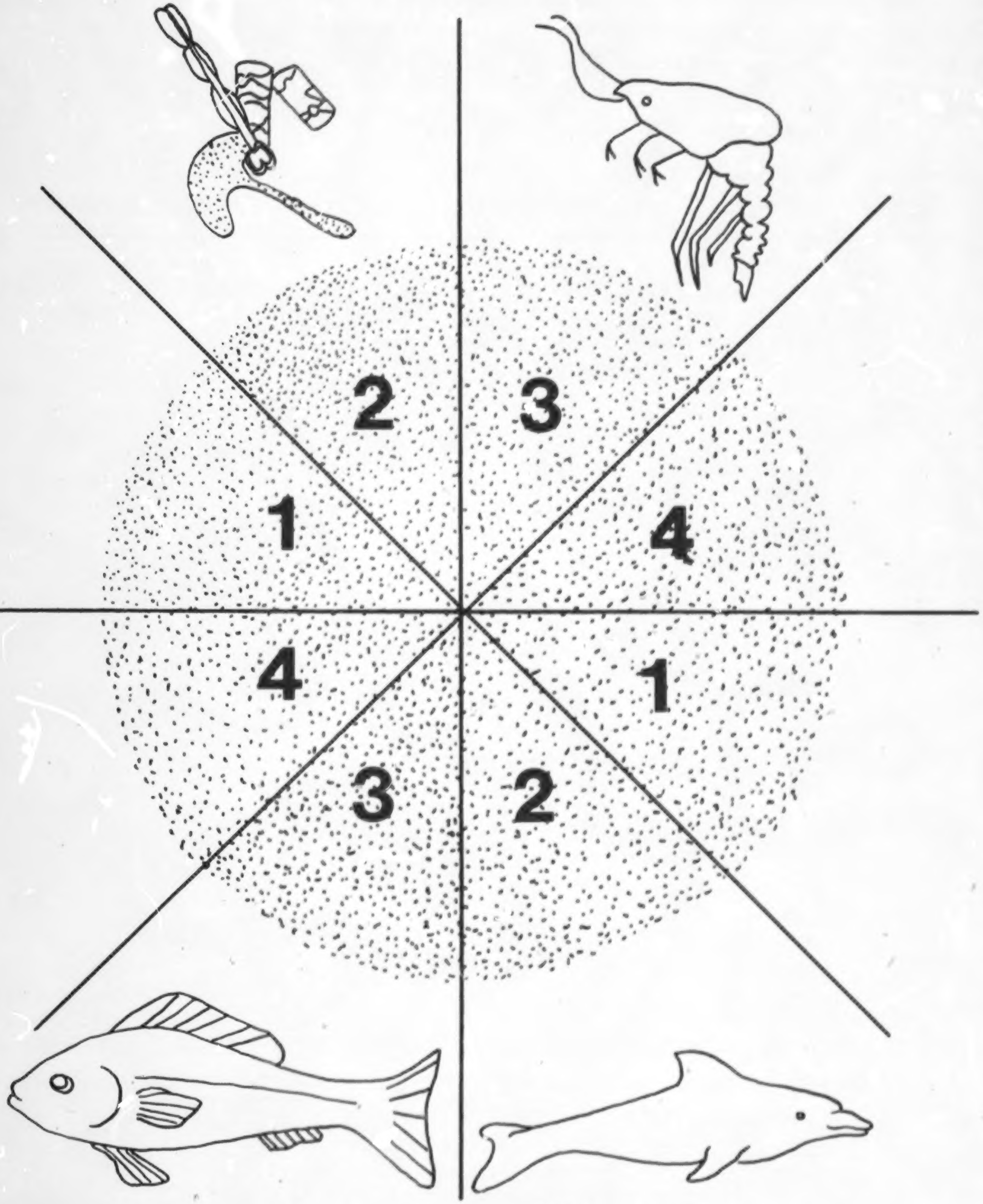
The purpose of this game is to create a dolphin using the following food chain: diatoms, copepods, oyster, crab, fish, dolphin.

Each feeding level (trophic level) of the chain represents a different amount of food material. Since only 10 percent of the material at each level is used to build the organism at the next higher level, it will take 4,000,000 pounds of diatoms, 400,000 pounds of copepods, 40,000 pounds of oyster, 4,000 pounds of crab and 400 pounds of fish to make one 40-pound adult dolphin.

Rules

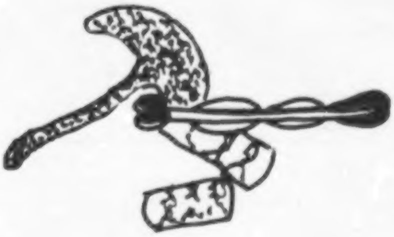
1. Two or more play.
2. One player is chosen to keep score and to hand out the food chain cards.
3. The player to spin the highest number is the starting player. The next player is the one to his left.
4. Each player is given a diatom card at the beginning of the game.
5. Players move through each link of the food chain by collecting the amount of weight written on the cards.
6. Each card states the value of the units on the spinner board. (e.g., #2 on board=2 unit times the value of a unit on the food chain card so if the card he had was diatoms he/she would receive 2x100,000-200,000 lbs meaning that he would have to spin a minimum of 2 in his/her next turns before he/she could receive the copepods card.
7. As each player reaches the amount written on his food chain card, or goes over it, he/she trades the card with the scorekeeper for the next card in the food chain.
8. The first player to move through the entire food chain to the dolphin becomes the winner.
9. Each player is allowed one spin at a time. The arrow must go around one full turn from its starting point. If it does not, or stops on a line, the player must spin again.

DOLPHIN



DIATOMS

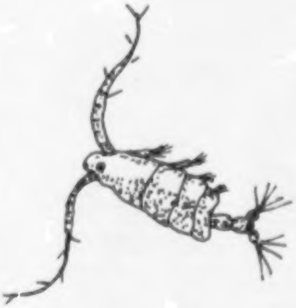
This card represents tiny sea plants (phytoplankton). It takes 4 million pounds of phytoplankton to make a dolphin.



Each unit on the wheel is worth 100,000 lbs.

COPEPODS

This card represents tiny sea animals (zooplankton). It will take four hundred thousand pounds of zooplankton to make a dolphin.



Each unit on the wheel is worth 10,000 lbs.

OYSTER

This card represents the oyster. It will take forty thousand pounds of oysters to make a dolphin.

Each unit on the wheel is worth 1,000 lbs.

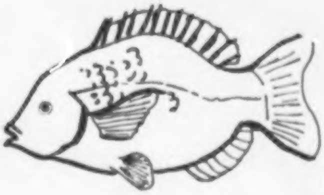
CRABS

This card represents crabs. It will take four thousand pounds of crabs to make a dolphin.

Each unit on the wheel is worth 100 lbs.

FISH

This card represents free-swimming fish. It will take four hundred pounds of fish to make a dolphin.



Each unit on the wheel is worth 100 lbs.

DOLPHIN

This card represents one forty pound dolphin.

FOOD PYRAMID
(Questions)

Answer:

1. Which organisms in the pyramid have the largest numbers? Are they consumers or producers?

2. Organisms at which level require the most energy? The least energy?

3. Which organism would give off the most energy as it is decomposed?

4. If you wanted to feed fish efficiently would you feed them a first order or second order consumer? Explain.

5. Using the food pyramid, can you offer a possible explanation of why it is that larger marine birds, like the Brown Pelican, have died from DDT which was sprayed on plants to kill insects?

6. With more and more people being born all the time, what must happen to the bottom of the food pyramid?

7. Which is more efficient for man to eat, grass or beef? Explain.

8. At the present when man eats fish, the food chain is algae, zooplankton, fish, fish, man. What would be the effect of man feeding algae and plankton to cattle and then eating the beef?

9. More and more plant materials are being used all the time to take the place of meat. Would you eat a "hamburger" made from algae or plankton? Why or why not?

10. With our population continually increasing should we consider using seaweeds and algae (algae flour, seaweed salads, soup and cookies, etc.) as food for man? Explain.

MANAGING A SMALL BAY AREA

Mr. and Mrs. C. Drift just bought land around a small bay. The bay does not contain any large fish that are exciting to catch. But there are some medium size fish such as croaker, mullet and perch. The diagram shows the food web in the bay area now.

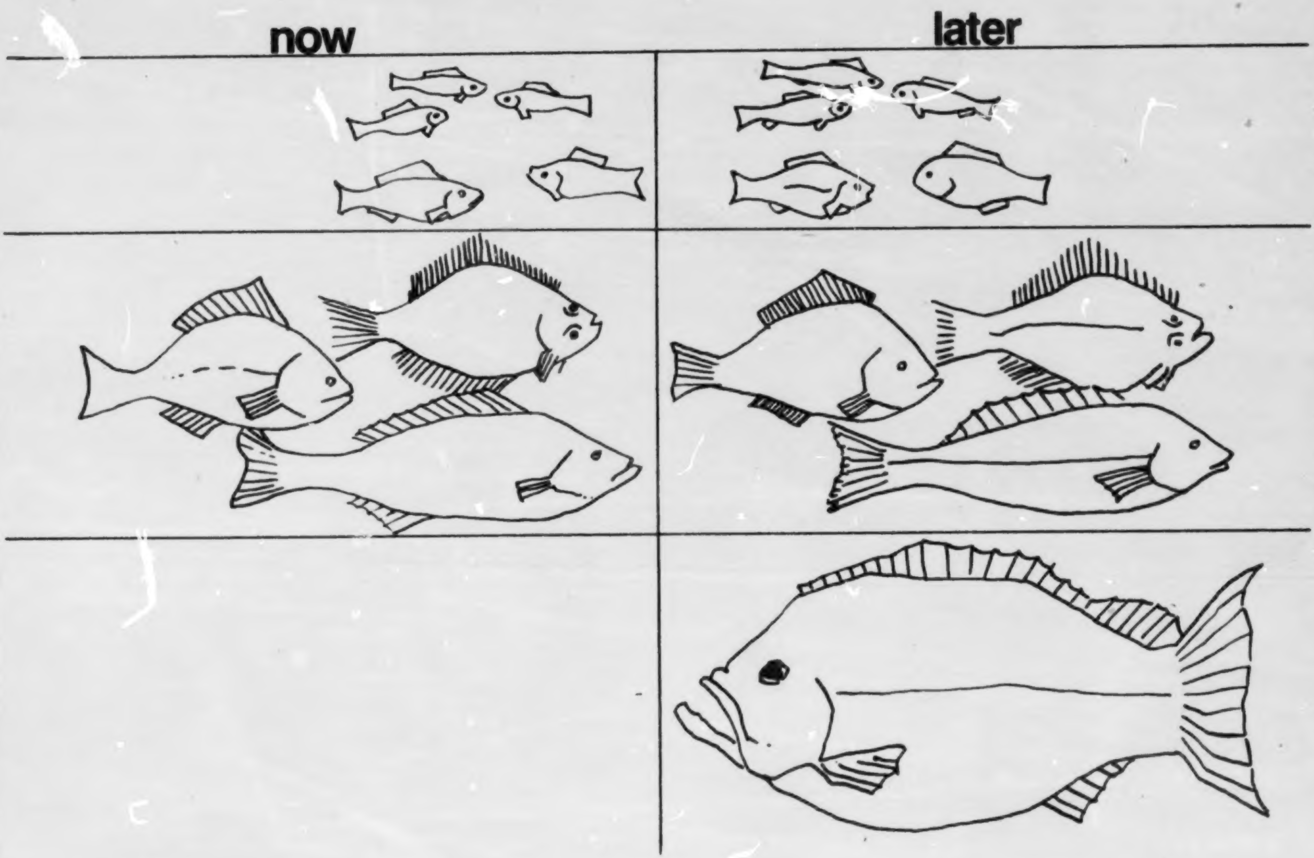
Around the bayshore there are weekend and vacation homes, boats to rent and a store that sells bait and food to the vacationers.

The Drifts want to attract more fishermen to the bay. They have decided to add a new species of fish to the bay. These new fish grow to a large size and are exciting to catch. Look at the Food Pyramid of a Bay diagram to see the pyramid now and what it would be if the fish were added.

The Drifts assume that the bay will support as many medium-sized fish as before, plus a good number of the new large fish. They think more fishermen will want to fish in the bay and the families who already came to fish for the medium size fish will still be satisfied and will continue to fish in the bay.

What do you think will happen with the new fish in the bay? Use the space below to write a statement to the Drifts. Tell them whether their plan will work. Give reasons to support your position.

FOOD PYRAMID OF A BAY



TOPIC EIGHT
THE BIG CIRCLE (CYCLES)

ACTIVITY ONE--The Circle of Water
ACTIVITY TWO--The Carbon-Oxygen Cycle
ACTIVITY THREE--The Nitrogen Cycle
ACTIVITY FOUR--The Not So Perfect Cycle

Materials for Classroom Use:

Water Resources/Reading
Water Cycle/Reading
Water Cycle/Drawing
Travels Through King Neptune's Domain
Water Cycle/Questions
The Carbon-Oxygen Cycle/Reading
Carbon-Oxygen Cycle/Drawing
Man and the Carbon-Oxygen Cycle/Reading
Carbon-Oxygen Cycle/Questions
Nitrogen Cycle/Reading
A Nitrogen Crisis?/Reading
Nitrogen Cycle/Questions
The Not So Perfect Cycle?Reading
Phosphorous Cycle/Drawing
Phosphorous Cycle/Questions

Major Objectives for the Topic:

After completing the activities the student will be able to:

1.4 diagram and explain each of the following cycles in marine ecosystems: water, oxygen, carbon, nitrogen and minerals;
1.4 conclude that all living things originally came from non-living material and also that the elements of which living things are made are basically the same as those of non-living materials and these elements move in cycles and are recycled;
1.4 identify the vehicles which carry out the processes of energy flow and nutrient recycling in a given marine ecosystem;
1.4 make inferences as to what would happen in each of the cycles if there were:
  (a) no plants present
  (b) no animals present
  (c) no microorganisms present
  (d) no sunlight
2.1 describe ways in which man has, could or will affect each cycle in the past, present and projected future;
2.3 appraise the effect of a given interruption (past, present and projected future) on each cycle.

Teaching Suggestions:

The purpose of this lesson is to present information to the student on material cycles and help him understand their role in an ecosystem.

1. The readings could be handed out the day before and read as a homework assignment.

2. The Travels Through King Neptune's Domain can be done individually or as a group. It could be a written activity or a presentation to the class. Having the students share their presentations with the class will provide more examples. The students may have trouble getting started so you may want to give an example or two with the class as a whole. One example could be: a rain drop falls on the soil, moves down into the soil, is absorbed by a root hair, goes into plant, gets back into the air by transpiration or ends up in another organism which eats the plant, etc. In another, the rain drop falls on the street, down the sewer into a waste treatment plant, into a stream where it could stay a while, be evaporated or removed by another city, processed through the water purification plant and then into the city water pipes, etc. King Neptune calls to learn where they are and what is happening. The variations are unlimited. Allow them to use the CB code words to increase interest.

3. After the class or groups complete the Water Cycle activities, you may want to use the Travels Through King Neptune's Domain idea to have the groups make a presentation on Travels Through Mother Earth's Domain based on the carbon-oxygen, nitrogen and phosphorous cycles. You might even have a different group present each different cycle.

4. Encourage the students to generate additional questions and to try to answer them cooperatively.

TOPIC EIGHT--THE BIG CIRCLE

THE CIRCLE OF WATER

Read--

The Water Cycle.

Look at--

The diagram of the Water Cycle.

Divide--

A sheet of paper into three columns. Label them as follows:

Precipitation, Transpiration, Evaporation
Water Coming From
Water Going To

Fill in the columns.

Divide--

Into groups to complete the Travels through King Neptune's Domain.

Present--

Your version of Travels through King Neptune's Domain to the class.

Read and Discuss--

Water Resources

Answer--

The questions on the Water Cycle.

WATER CYCLE

So you don't live near the ocean. And you think that it doesn't matter to you. Wrong!

Water is the substance which makes the earth unique. It is the most abundant single substance on the earth. Almost three-fourths of our body weight is water, so we are actually water creatures. Some forms of life can live without air, but none can live without water. With all the water available on the earth, less than one percent of the world's water is special to us--this is the usable kind of water we drink and use everyday in countless ways.

Look at the global circle in which water moves. Water is evaporated from the oceans and from land and is taken into the atmosphere. There it travels as invisible water vapor or visible clouds until it falls back to earth as rain, hail, sleet or snow. It is absorbed back into the earth and reappears in rivers, streams, and lakes and eventually back to the sea.

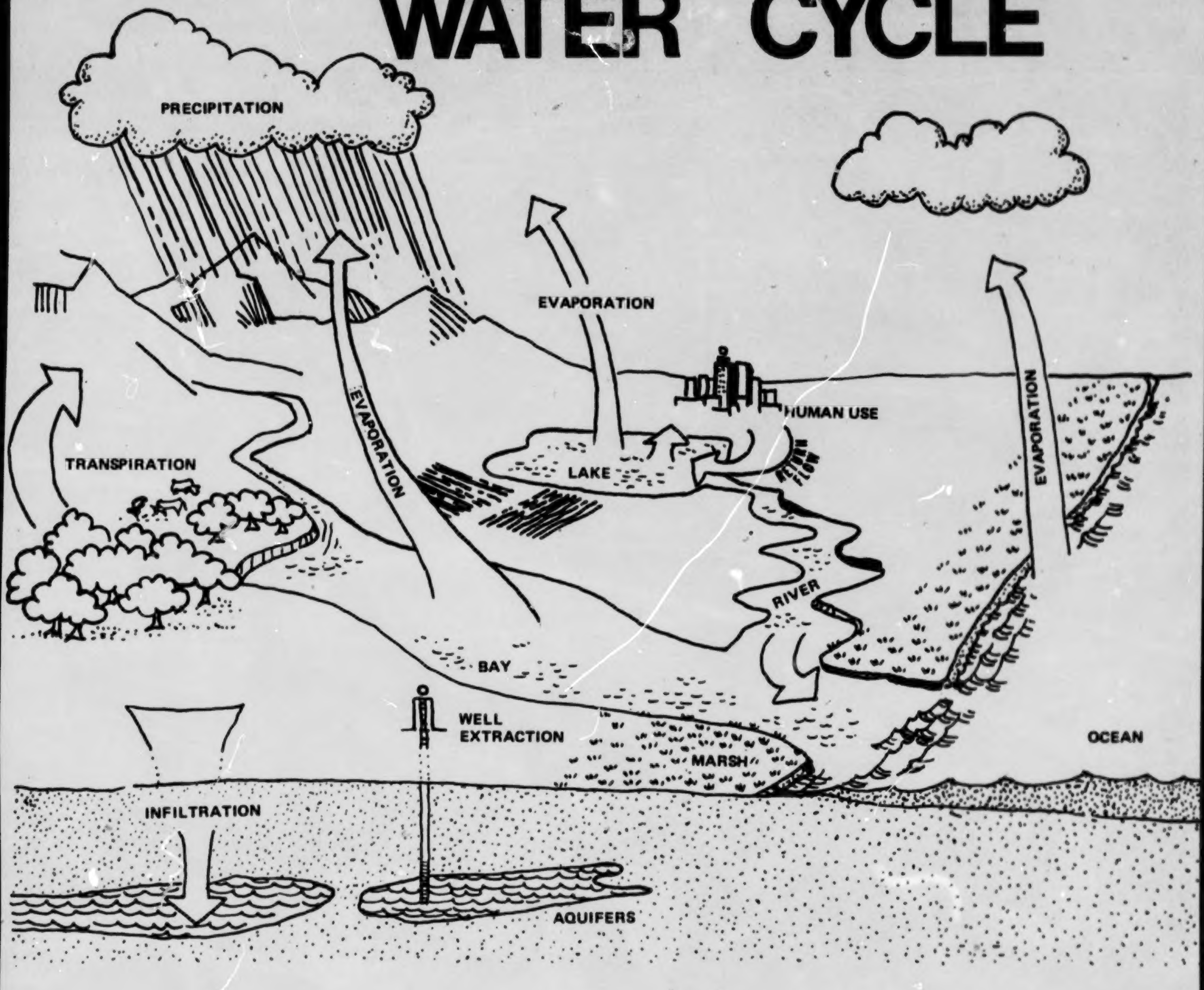
Much of the soil water is taken up by plants. Plants on land and in the water itself use the oxygen and hydrogen from water to make sugars and starches. The water also has dissolved in it nutrients needed by plants and animals. Excess water is evaporated from the land plants through small pores in the leaves--this is transpiration. Water is also added to the air by the respiration of animals and by the decomposition of decaying materials. The largest part evaporates from the oceans, with the remainder coming from land and land waters.

The water that goes out from the surface of the earth returns in equal amounts, creating a cycle. While this cycle is balanced for the whole planet, the rates of precipitation and evaporation for individual areas vary. The amount of water on the earth does not increase or decrease, it is unchanging. It is all part of a cycle in which water is not "lost", but changes form or locality.

The irony of the water cycle is most obvious along the southern Texas coast which is surrounded by water, but where usable water is scarce. The salt water of the Gulf is still a resource, but to meet man's and the wetlands' needs for fresh water, ocean water must be recycled through the processes of evaporation, rainfall and runoff.

The water cycle also points out that there are not many oceans or seven seas. There is only one body of water surrounding our planet and running through our countries, our bodies and our lives. Therefore, as citizens of a water planet, we must realize that any misuse of water, wherever it occurs, has effects that extend around the globe and into each of our lives. Usable fresh water is the limiting natural factor in not only the Texas coastal region but all over the world.

WATER CYCLE


PRECIPITATION
EVAPORATION
TRANSPIRATION
EVAPORATION
HUMAN USE
LAKE
RETURN FLOW
EVAPORATION
RIVER
BAY
WELL
EXTRACTION
MARSH
OCEAN
INFILTRATION
AQUIFERS

TRAVELS THROUGH KING NEPTUNE'S DOMAIN

Imagine that you are a water drop in a cloud. Then under the right conditions you leave the cloud to fall to earth--become rain drops. You all land in various places: farmland, ranch land, mountains, streams, lakes, on buildings, streets, sidewalks, etc. King Neptune, the god of water, is at his CB base station making contact with you on the CB hydrophone to learn your location and how you are doing.

Your group is to compile a presentation in which King Neptune uses his CB hydrophone to talk to the rest of your group (you also can talk to King Neptune) who are water droplets that become rain drops and eventually get back to the cloud by evaporation. The description of your travels and experiences will be presented through your CB conversations with King Neptune.

Write the outline for your group's presentation below. Each member of the group should list the different places he travels to and the experiences he has.

WATER RESOURCES

MEMO TO: Captain Al G. Seaborne FROM: Wally Rainstorm

From the pine forests of East Texas to the farmland of the west, from the Red River south to the Gulf Coast, there is a common Texas problem - water.

Sometimes there is too much water, more often too little. It's brackish here, salty there. It flows wildly in some regions, not at all in other areas. It is a very valuable but limited resource. People, industry and agriculture must have water.

Texas is an example of the problem in the United States. We have rainfall from 6 inches in the west to 90 inches in the East. We have the desert and the lush plains and forests.

A doomsday projection could paint an ugly picture of the future of Texas.

- Houston sinking into Galveston Bay
- Dallas-Fort Worth losing its growth potential
- The fertile High Plains and Lubbock turning into a desert
- The Rio Grande Valley's recreation, retirement and economic growth stopping
- Hundreds of small towns facing enormous expenses to provide water
- El Paso depleting its ground water
- Cities fighting over water rights
- Salt deposits polluting major waterways

and on and on because of our withdrawal of underground water.

We are not doomed, but we do have critical problems. The state has a relatively adequate water supply at present. However, increasing population and dropping ground water supplies pose a critical situation for the years ahead.

Three-fourths of the earth's surface is covered by water - mostly salt water. We cannot drink it and most plants cannot grow in it. Can we take the salt out of the sea water and get fresh water? Can we do it cheaply enough to make it practical for drinking, farming and other uses? Scientists have found the answer to the first question and are trying many methods to answer the second.

Sincerely,

Wally

Wally

WATER CYCLE QUESTIONS

1. What is the source of energy that moves water in the cycle?

2. Explain the statement "The water you drank today may have been used by Adam and Eve to cook their food."

3. What is the role of living organisms in the water cycle?

4. What forms does water take in the cycle?

5. How is the water cycle related to our weather and climate?

6. Why is the water cycle important to marine organisms?

7. How does and can man affect the cycle?

TOPIC EIGHT--THE BIG CIRCLE

THE CARBON--OXYGEN CYCLE

Read--

The Carbon--Oxygen Cycle.

Look at--

Diagram of the carbon-oxygen cycles.

Read--

Man and the carbon-oxygen cycle.

Divide--

A sheet of paper into five columns. Label them as follows:

Carbon Coming From
Carbon Going To
Oxygen Coming From
Oxygen Going To

Complete the information in the columns.

Answer--

The questions on the carbon-oxygen cycles.

Create and Present--

Your version of travels through Mother Earth's Domain based on the carbon-oxygen cycle.

THE CARBON--OXYGEN CYCLE

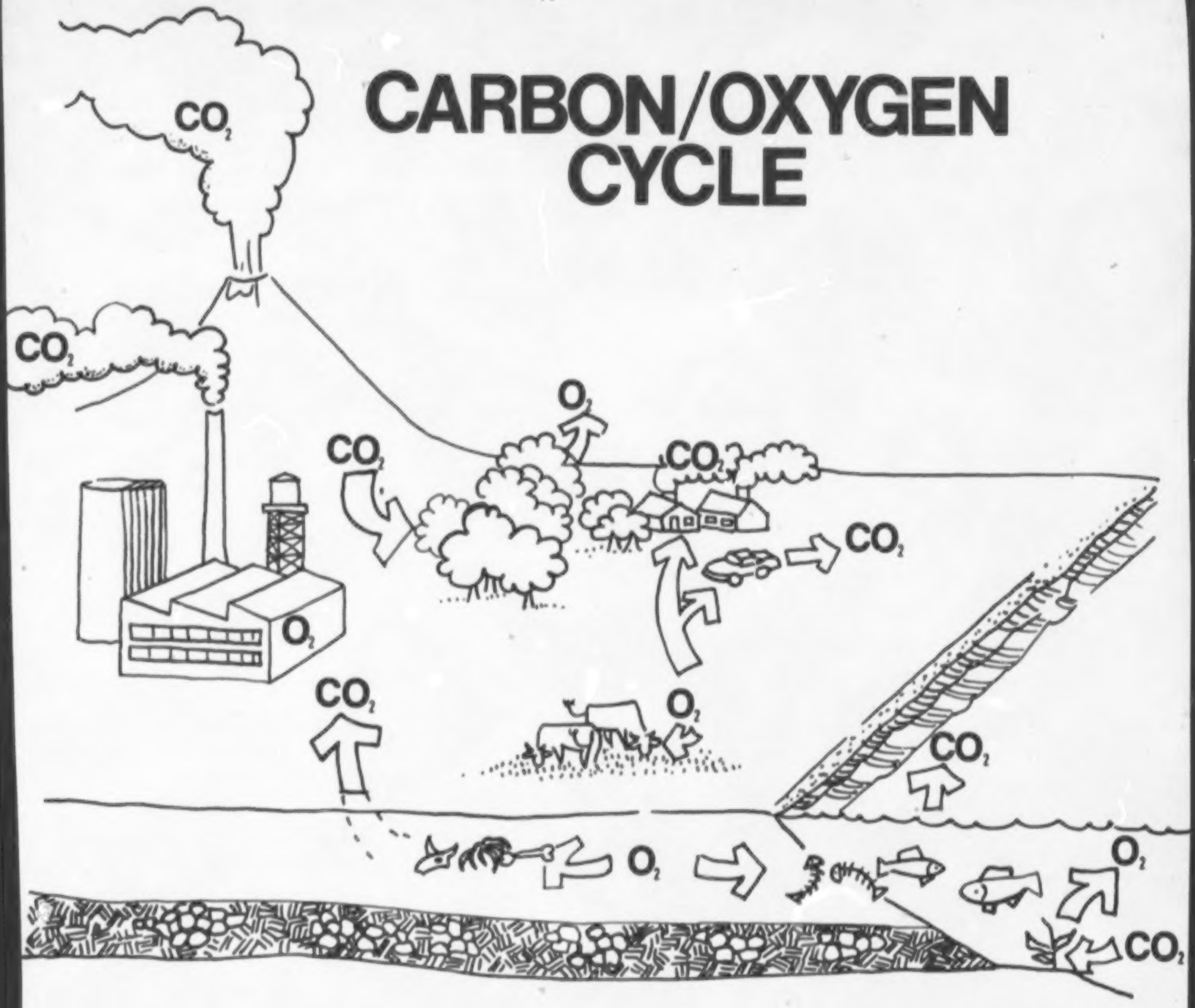
Carbon and oxygen are life's major building blocks. About every fourth atom in the body of an organism is an oxygen atom. Starches, sugars, fats, proteins, ATP, DNA and RNA are all molecules which are made of a skeleton of carbon atoms. We cannot live without them. The amount of carbon and oxygen on earth does not change, only its location and form in the cycle.

Oxygen in the atmosphere is found as O_2--two oxygen atoms bonded together. Photosynthesis is the process by which oxygen is produced and released to the atmosphere. This is done by plants using energy from the sun and water to make carbohydrates. Plants of the oceans produce over 85% of the earth's oxygen. Oxygen is taken from the atmosphere by plants and animals during the process of respiration, the decomposition of decaying materials and the burning of fuels--coal, oil, wood.

Carbon travels in its cycle as carbon dioxide (CO_2) combined with two oxygen atoms. During photosynthesis, carbon dioxide is removed from the atmosphere. Plants use it along with energy from the sun and water to make carbon compounds. Carbon dioxide is released to the atmosphere through the respiration of plants and animals, decomposition, the burning of oil, coal and wood and volcanic eruptions.

If it were not for the decomposers, all carbon would be locked up in organic matter that could not decay. If there were no plants, there would be no oxygen. If there were no oxygen, there would be very little life on earth. Therefore, living organisms depend on one another to stay alive.

CARBON/OXYGEN CYCLE


CO2
CO2
O2
CO2
CO2
CO2
O2
CO2
O2
CO2
O2
O2
CO2

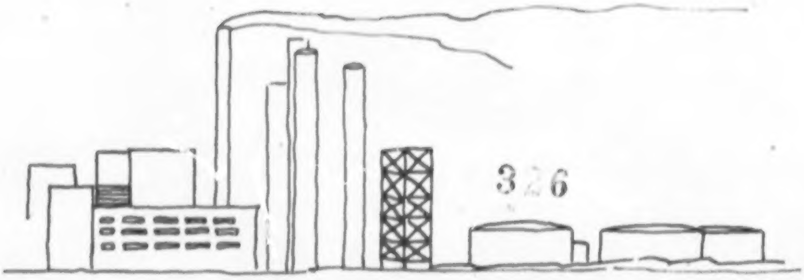
MAN AND CARBON--OXYGEN CYCLE

Man has had a tremendous impact on the carbon-oxygen cycle although we have no precise evaluation of man's effect. Let us look at some potential problems.

Suppose the supply of oxygen to the atmosphere were cut off. This could be caused by something interrupting photosynthesis by the phytoplankton in the sea or plants on land. Phytoplankton need light to carry on photosynthesis. What kind of effect would a thin layer of oil or other contaminates, such as pesticides and mercury, have on organisms that are necessary to the environment? Scientists worry about such questions because they don't know the answers.

Sewage and pollutants are being added to bays, salt marshes, estuaries and the ocean itself. This would lead to an increase in the decomposers. They would use more oxygen to break down the wastes. This would leave less oxygen, and maybe none, for the crabs, shrimp and fish. Without oxygen they would die. Again scientists don't have an answer.

Another big question is related to the amount of carbon dioxide in the atmosphere. Carbon dioxide in the atmosphere causes what is called "the greenhouse effect," In other words, carbon dioxide acts like the roof of a greenhouse by holding heat close to the earth. What will happen if man dumps too much carbon dioxide into the atmosphere by burning fossil fuel (coal and oil)? For one thing, plant growth would be speeded up. The average temperature of the earth also may increase which would cause the polar ice to melt, raising the level of the oceans and flooding many coastal cities. It would also mean a decline in agricultural production. Man may run out of fossil fuels before this could happen, however. Again, science has not found the answer.



QUESTIONS ON CARBON-OXYGEN CYCLE

1. What is the role of animals in the cycle?

2. What is the role of plants in the cycle?

3. What organisms use oxygen and for what purpose?

4. Why is all the oxygen in the form of O_2 considered to have originated from a living organism?

5. What role do bacteria play in the cycle?

6. What effect will the following activities of man have on the cycle?
   A) Removing plants

   B) Using more fossil fuels-coal, oil, gas

   C) Using herbicides to kill unwanted plants in bays and waterways

TOPIC EIGHT--THE BIG CIRCLE

THE NITROGEN CYCLE

Read--

Nitrogen Cycle
A Nitrogen Crisis?

Look at--

Diagram of the Nitrogen Cycle.

Divide--

A sheet of paper into three columns. Label them as follows:

Part of Cycle
Nitrogen Coming From
Nitrogen Going To

Fill in the columns.

Answer--

The questions on the nitrogen cycle.

Create and present--

Your version of travels through Mother Earth's domain based on the Nitrogen cycle.

NITROGEN CYCLE

Nitrogen is needed by all living things. It is an important part of proteins, DNA, RNA and ATP. Four-fifths of the earth's atmosphere is nitrogen gas owever, only very few plants and animals can use it in this form.

The nitrogen must be "fixed" by plants such as legumes so it can be used by other organisms. Most of the nitrogen fixers are microorganisms, bacteria and algae, but it also is fixed by marine organisms. Once fixed, it can be used by other organisms.

There are several pathways fixed nitrogen can take. One is from the nitrogen-fixing plant to the animal that eats it. When the animal decays, the nitrogen compounds are released and can be reused by the plants. In this cycle, nitrogen does not get back to the atmosphere. A variation of this cycle is that some of the nitrogen released from animal or plant bodies by decomposure goes into the soil. Instead of being reused by a plant, it is washed out of soil and enters the water. Here it may enter any number of different marine food webs.

A third pathway actually releases nitrogen back to the atmosphere. This is done by denitrifying bacteria in the soil. The cycle is complete. Nitrogen goes through many chemical changes in its cycle, and all of them depend, in some way, on bacteria. However, we still do not know how it occurs in marine habitats.

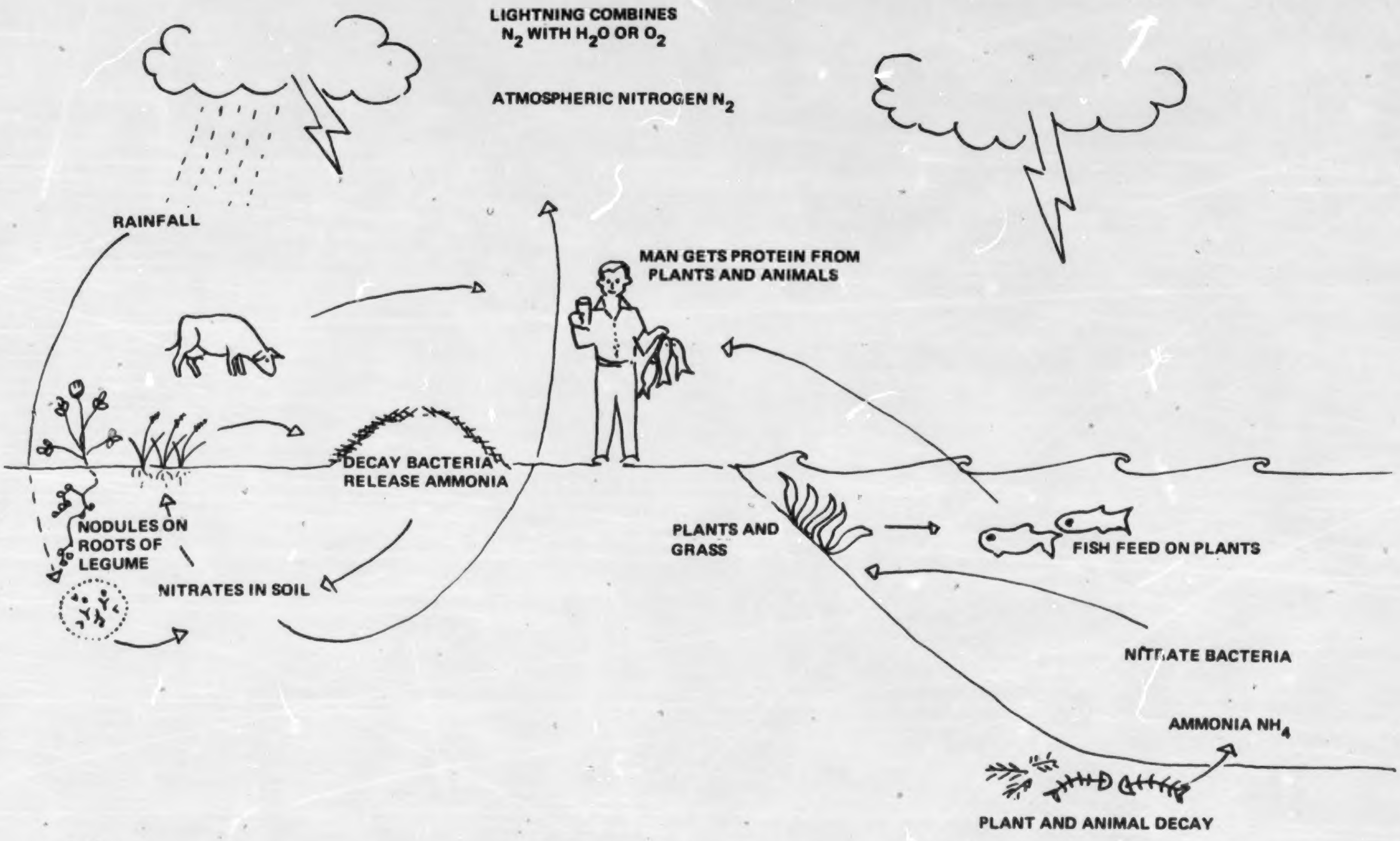
A NITROGEN CRISIS?

Are we going to have a nitrogen crisis? One of the most significant things that man has done to disrupt the natural cycles on earth is the large scale dumping of fixed nitrogen in the form of fertilizer. It amounts to about 30 million metric tons per year. This is done to increase agricultural crop yields, which is a necessity if all humans on earth are going to have food. Right now, the phase which returns nitrogen to the atmosphere is far behind the input phase of the cycle. The imbalance will get worse in the future as demands on crop production increase. How long can the nitrogen cycle stay out of balance? What will happen after millions and millions of tons of fixed nitrogen are added to the soil? Right now nobody knows what may happen.

We do know what happens if the nitrates (nitrogen compounds) are greatly increased in lakes, bays and estuaries. It causes a rapid increase in certain algae. Often the growth is so great that the algae either covers the water or colors it. This is an algal bloom.

The algal bloom greatly increases the quantity of living material in a body of water. The large amount of algae will eventually die. The increased dead matter triggers an explosion of the bacterial decomposers. The decomposers release nutrients from the dead algae to the water. These nutrients cause another algae growth. This causes more dead algae and more bacterial decomposers. The overall result is a cycle, but one that does not continue forever. The decomposers use oxygen that is dissolved in the water. This is the same oxygen that all the other animals in the lake use. Eventually, the decomposers use so much of the oxygen that two things happen: (1) the fish and other animals that need large amounts of oxygen die, and (2) the decomposers die. The dead matter--plants, animals and decomposers--collect on the bottom and age the lake. The overall process of aging is called "eutrophication." Could we do this to the Gulf of Mexico or the oceans with our dumping of sewage and fertilizers? We have done it to Lake Erie.

NITROGEN CYCLE



LIGHTNING COMBINES
N_2 WITH H_2O OR O_2

ATMOSPHERIC NITROGEN N_2

RAINFALL

MAN GETS PROTEIN FROM
PLANTS AND ANIMALS

DECAY BACTERIA
RELEASE AMMONIA

NODULES ON
ROOTS OF
LEGUME

NITRATES IN SOIL

PLANTS AND
GRASS

FISH FEED ON PLANTS

NITRATE BACTERIA

AMMONIA NH_4

PLANT AND ANIMAL DECAY

NITROGEN CYCLE QUESTIONS

1. What organisms are needed to change nitrogen to the different chemical forms?

2. Why does man need nitrogen?

3. How does man get nitrogen?

4. What would happen to the cycle if all decomposers were destroyed by chemical pollution?

5. How is man affecting this cycle?

6. How do you think man will affect this cycle in the future?

TOPIC EIGHT--THE BIG CIRCLE

THE NOT SO PERFECT CYCLE

Read--

The Not So Perfect Cycle.

Look at--

Diagram of the Phosphorous Cycle.

Divide--

A sheet of paper into three columns. Label them as follows:

Part of Cycle
Phosphorous Coming From
Phosphorous Going To

Fill in the columns.

Answer--

The questions on the phosphorous cycle.

Create and present--

Your version of travels through Mother Earth's domain based on the phosphorous cycle.

THE NOT SO PERFECT CYCLE

Oxygen, carbon and nitrogen are only three of the elements needed by organisms. There are many more that are needed in smaller quantities and must be recycled. Of these elements, phosphorous is a typical example we can use to show a different type of cycle.

Phosphorous, like many other essential elements and minerals, is not normally found in the atmoshpere. In the carbon, oxygen and nitrogen cycles the atmosphere served as a "storage bank" from which they could be withdrawn and deposited. The cycle of phosphorous does not include this "storage bank."

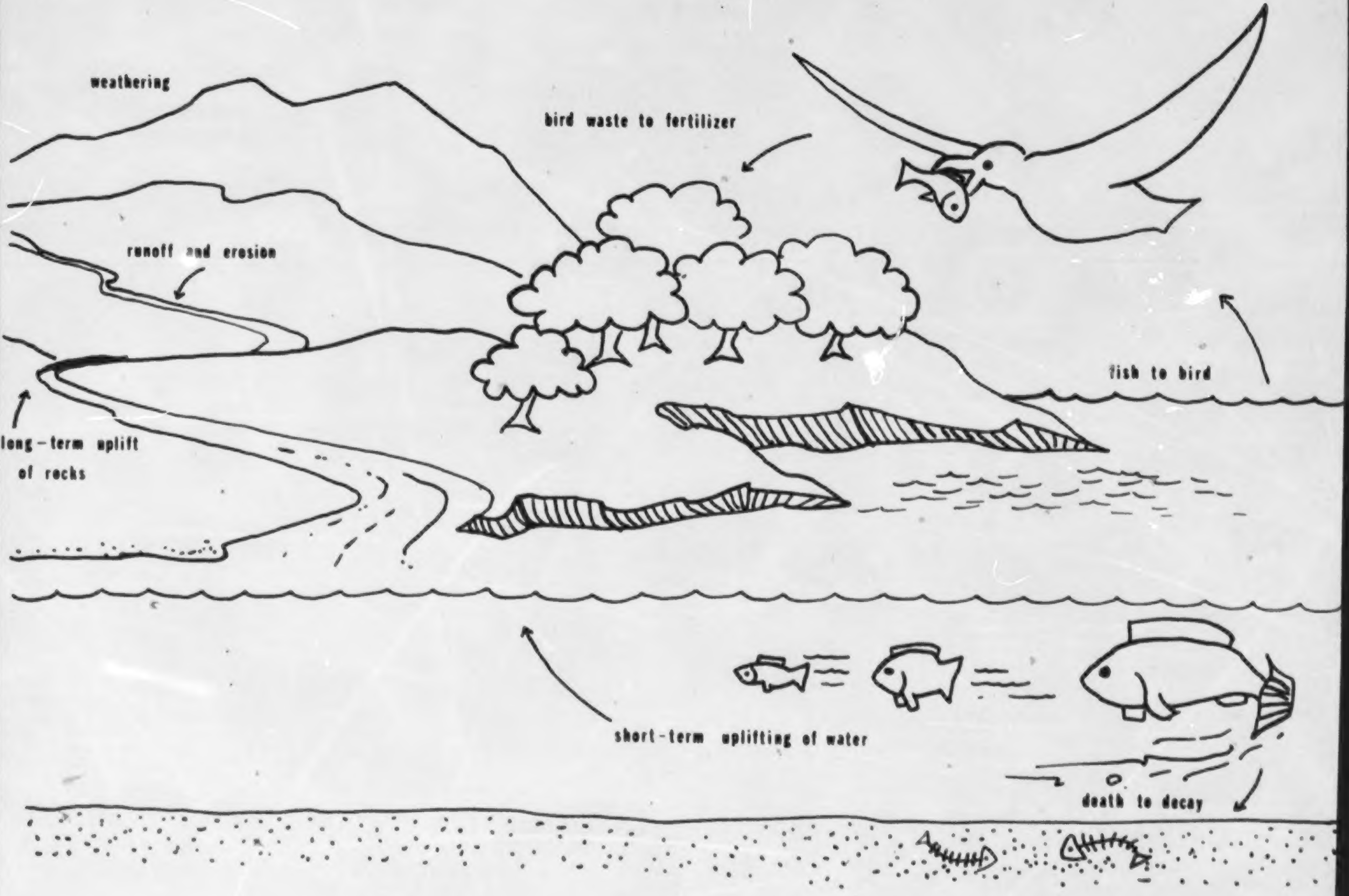
Phosphorous is present mainly in the form of phosphate rocks. Throughout the years, these rocks are broken down by weathering and erosion. Some phosphorous will remain in the soil and be used by plants. In the land ecosystems, the phosphorous will be cycled from the bodies of plants to animals, and then back to plants by the decomposers.

Some of the phosphorous will be washed into the aquatic and marine ecosystems and will be carried into the oceans. The cycle is not perfect in marine waters. There is actually a loss of phosphorous from the cycle in marine ecosystems. Some of the phosphorous settles to the bottom of the ocean and forms phosphate rocks. Therefore it is normally a one-way cycle ending in the sea.

There is an interesting exception to this one-way path. This may be of some importance in returning phosphorous to the land. On certain islands there are tons of phosphates that have been deposited over the years from the wastes of sea birds. This material, called "guano," also contains nitrogen. For many years it was one of man's chief sources of fertilizer. Therefore, some of the phosphate lost in the sea is returned (about 5%) to the land by sea birds, thus completing the phosphorous cycle.

As with the other cycles, man is affecting the phosphorous cycle. Like nitrogen, phosphorous is also causing problems in water because of eutrophication. This is a result of the increased use of phosphate fertilizer and phosphates in detergents. What will happen? Will there be more cases of eutrophication?

PHOSPHOROUS CYCLE


weathering
bird waste to fertilizer
runoff and erosion
fish to bird
long-term uplift of rocks
short-term uplifting of water
death to decay

PHOSPHOROUS CYCLE QUESTIONS

1. Why is phosphorous needed?

2. Why are the phosphorous and other mineral cycles called non-perfect cycles?

3. How could man's addition of fertilizers and detergents containing phosphates affect this cycle?

4. Some ecologists fear that we will use up all our phosphates, nitrogen and other fertilizers because they will be washed out of the soil and deposited in the oceans. Explain why they are saying this.

TOPIC NINE
SUM IT UP

ACTIVITY ONE--Man and the Marine Environment
ACTIVITY TWO--Plan for the Future

Materials for Classroom Use:

- What Do You Say?/activity
- Spaceship Earth/reading
- I am only One/reading and response
- Mercury in Lavaca Bay/reading
- "Super-Preservative" for Sale??/ activity
- It's Your Decision/activity
- A Mariculture System for the Future/activity
- P.S./activity
- Newspapers
- Magazines
- Glue
- Scissors
- Coloring and writing materials

Major Objectives for the Topic:

After completing the activities the student will be able to:

1.4 construct a future cycle of a marine ecosystem;
2.1 interpret man's relationship to the environment in the statement that man is a part of nature rather than above or outside of nature;
2.1 give examples of ways man's activity can be beneficial to to the energy flow and the nutrient cycle;
2.1 comprehend that man can and does affect the process of energy flow and nutrient cycling;
2.1 illustrate ways man can be damaging to the energy flow and nutrient cycle (oil spills, pesticides, dredging, etc.;
2.1 analyze newspaper and magazine articles for evidence of man's effect on energy flow and the cycles;
3.1 evaluate a particular individual act in relation to the environment;
3.1 discuss the idea that men are responsible for their activities;
3.4 devise a plan for improving the productivity of wide ocean areas by controlling or improving the process of energy flow and nutrient cycling (mariculture);
4.3 evaluate his position concerning the marine environment;
4.3 advocate a position in relation to the marine environment.

Teaching Suggestions:

The purpose of this lesson is to have students identify ways in which man is affecting the process of energy flow and nutrient cycling and to propose responsible management of the marine environment.

1. The activities are designed to be summary activities for students to think about the ways in which man does or can interact with the marine organisms and their environment. Knowledge gained from the previous topics should be used to complete the activities in this section. There are no set answers for many of the activities. Encourage the students to generate related information and questions and then strive to research and answer them.

2. Have the students complete the readings and respond to the activities and sketch. (This may be done by distributing the materials on the previous day.) Discuss the activities in small groups and/or as a whole class.

3. A homework assignment could be to collect newspapers and magazine pictures and articles that show evidence of man's effect on energy flow or nutrient cycling. The students can make the collage individually or in small groups.

4. The Mariculture System of the Future may be planned by groups of students or by the class as a whole. They are to use their knowledge gained from the previous topics to plan their mariculture system. This could be a simple or a detailed activity based on the time available.

5. The P.S. activity is one for each student to complete individually. It could serve as an evaluation of the previous activities or unit. You also could use it as a final class discussion after each student has completed it individually.

6. Additional references are:

National Geographic Magazine

The Imperiled Everglades, Vol. 141, No. 1 (Jan. 1972) pp. 1-27.
Fragile Nurseries of the Sea-Can We Save Our Salt Marshes?
    Vol. 141, No. 6 (June 1972) pp. 729-765.

Texas Parks & Wildlife Magazine

Die-off, Vol. 32, No. 3 (March 1974) pp. 2-5.
Young Naturalist: Predator-Prey Relationship, Vol. 32, No. 12
    (Dec. 1974) pp. 28-31.
Transplanted Plants, Vol. 34, No. 3 (March 1976) pp. 2-5.
Gambusia (Mosquito Control is this Fish's Role in the Ecological
    System), Vol. 34, No. 12 (Dec. 1976) pp. 16-17.
Young Naturalist: Water, Vol. 35, No. 4 (April 1977) pp. 28-31.

TOPIC NINE--SUM IT UP

MAN AND THE MARINE ENVIRONMENT

Complete--

What Do You Say? activity.

Read--

Spaceship Earth
I Am Only One
Mercury in Lavaca Bay

Write--

Your answer to "Super-preservative" for Sale?

Share--

Your answers and your reasons with your classmates.

Make--

Your choice and defend it in "It's Your Decision."

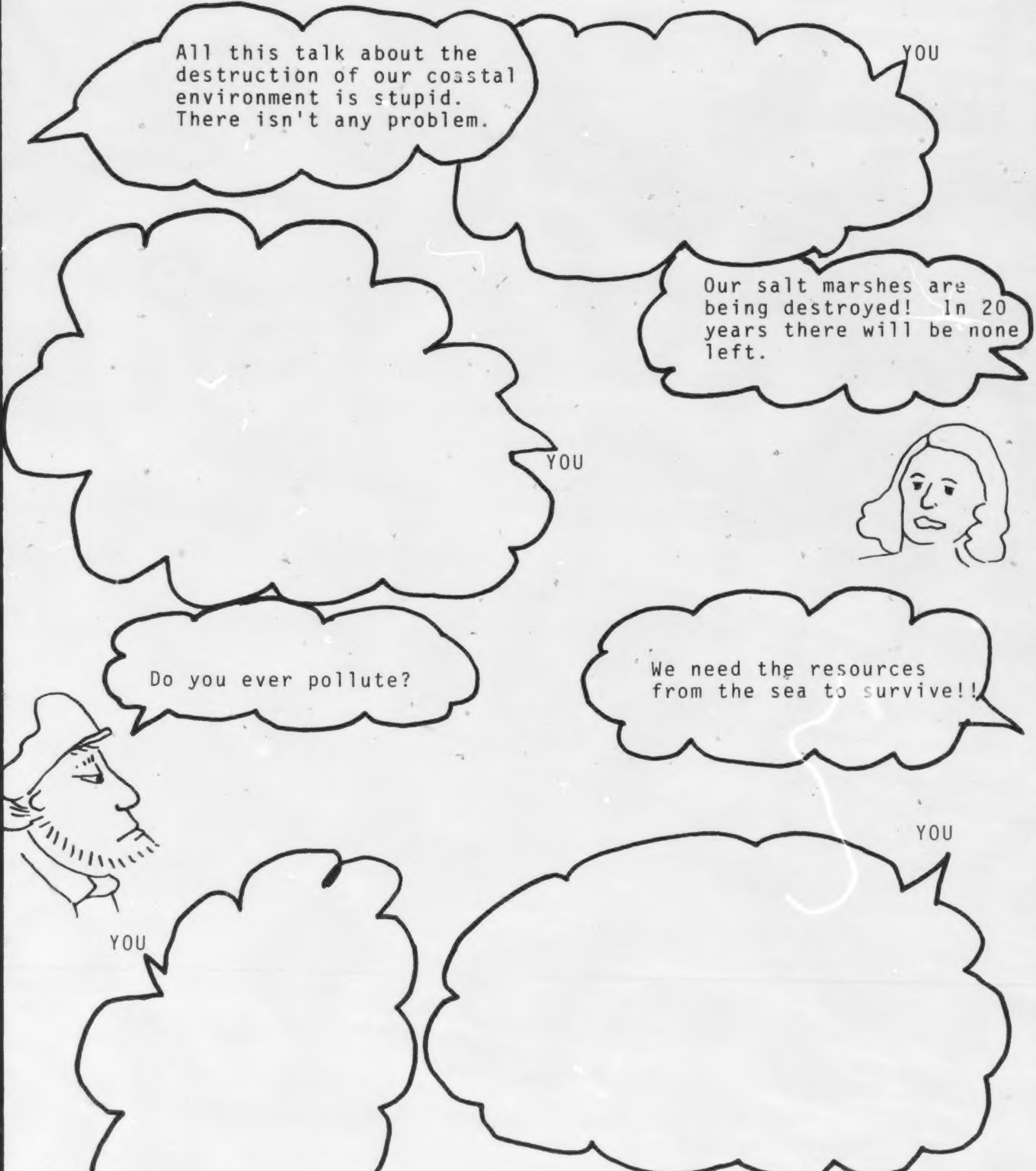
Collect--

Newspaper and magazine pictures and articles that show evidence of man's effect on food webs or the material cycles.

Make--

A collage using the materials collected to illustrate man's intervention in the ecosphere.

WHAT DO YOU SAY ?


All this talk about the destruction of our coastal environment is stupid. There isn't any problem.
YOU
Our salt marshes are being destroyed! In 20 years there will be none left.
YOU
Do you ever pollute?
We need the resources from the sea to survive!!
YOU
YOU

SPACESHIP EARTH

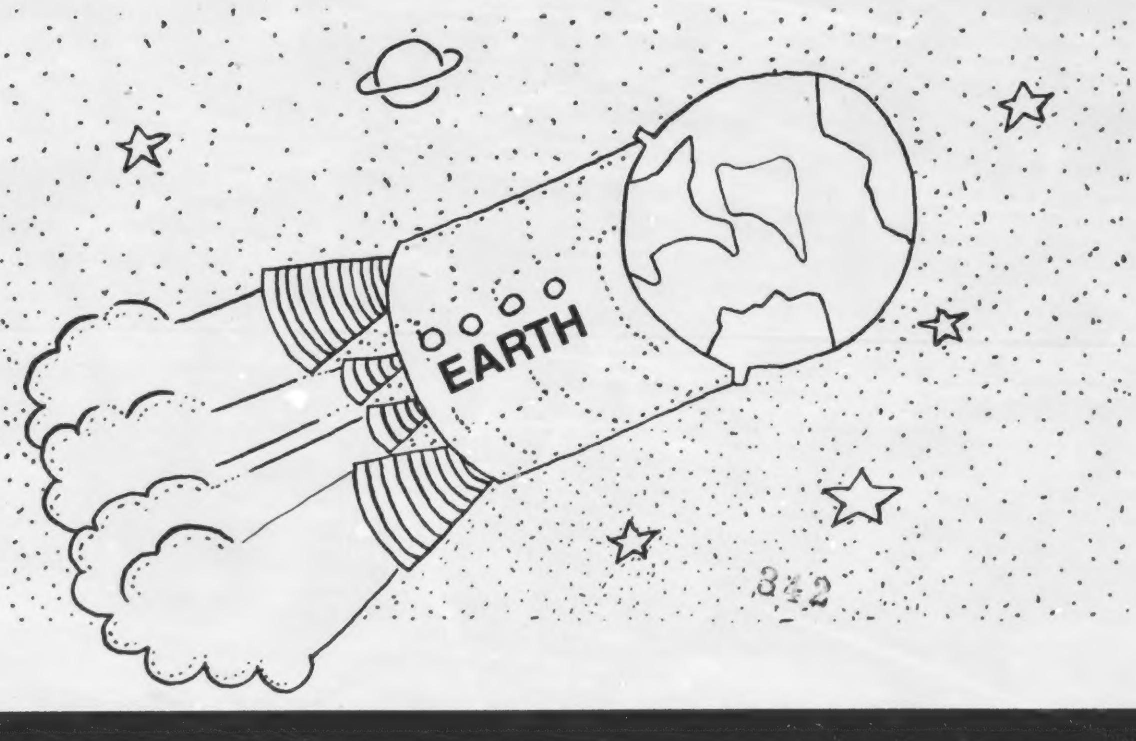
The earth is a giant ecosystem which Lamont Cole called "ecosphere." As an ecosphere, the earth may be compared to a giant spaceship; this means that the earth receives only energy from the outside. The earth receives no materials from the outside, all it has are already on it.

Like a spaceship, the earth's capacity to receive wastes is limited. Life on a spaceship does not survive without fresh water, neither can life on earth. Life on a spaceship cannot obtain food from the outside, neither can life on earth. Life on a spaceship can probably discard its wastes; life on earth cannot yet do this. Therefore, life on earth must learn to live with its wastes or reuse them.

The earth is like a spaceship which can get no new materials or get rid of its wastes. So it must recycle the materials and make sure the cycles keep operating.

The cycles are kept in operation by organisms. These organisms struggle to stay alive, to get food, to grow and to reproduce. The cycles depend on the organisms and the organisms depend on the cycles. They cannot survive without each other. Every organism is important and has a role in keeping spaceship earth alive. If enough individuals are destroyed, spaceship earth will be changed.

What can you do to make sure that spaceship earth is kept working and alive?



I AM ONLY ONE

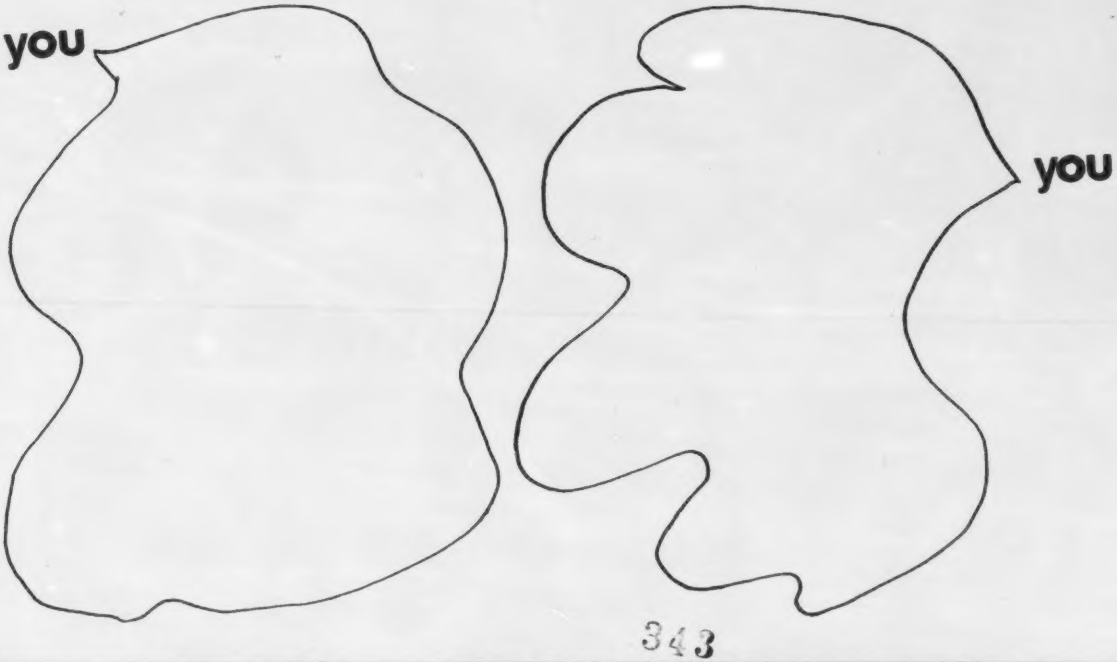
I am only one. I am not affecting the oceans. Someone else is doing it. The chemical plants are doing the polluting. The oil refineries and industrial plants are doing it, not me!

Pollution problems are usually blamed on industries and the needs of large cities. We don't think that the industries are in business because some of us want their products. Most people don't think they personally pollute their own environment, at least not seriously.

Think about the materials that you probably add to the water or soil. For example, when you wash a car, fertilize the lawn, take a bath, or even brush your teeth, you add new substances to the environment.

The soaps, toothpastes and chemicals, along with human wastes, go into a drain or a sewer. Some cities may have sewage plants to partially treat the wastes. But whether the wastes are treated or not, most of the substances you add to the water cannot be removed. The sewer finally empties into a river and it into the ocean. Some chemicals get into water in another way. Fertilizers and weed killers often sink down through the soil into underground water sources. This water eventually drains into streams and lakes and finally the ocean. Do you think these chemicals affect our waters and the living things in them? Do you think about how these substances affect food webs and material cycles? Do you think about pollution when you run soapy bath water down the drain? Should you?

Your response is:



MERCURY IN LAVACA BAY

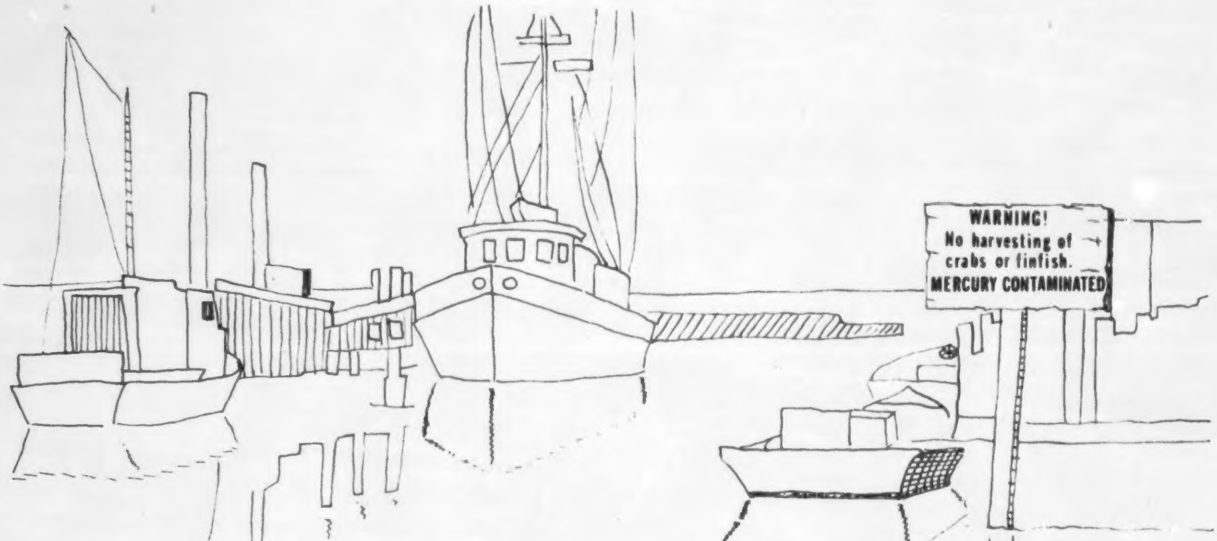
Picture a bay with plenty of fish, crabs and shellfish. It has also boat ramps, piers and a state park. Sounds perfect for the weekend fisherman.

Wrong! Below the surface the picture is different. It is the only fishing area in the state where the fish and crabs have unsafe levels of mercury. This became a problem in 1970 when the U.S. Food and Drug Administration found that the oysters and crabs from Lavaca Bay had high mercury levels. These levels were higher than one-half parts per million, which is considered safe for man to eat.

The culprit was an industrial plant near Point Comfort. The plant immediately changed its procedures. In four months the oysters returned to normal, but the crabs continued to have high levels of mercury. The theory is that the mercury in the bay sediments is eaten by small organisms. These small organisms are then eaten by crabs and fish. The mercury builds up in the fish's tissue and continues as long as the fish eat contaminated organisms.

So even in 1978, the state has had to re-issue warmings against harvesting crabs and finfish. They could be harmful if eaten regulary. Recent samples have had mercury levels from just over the safe level to as high as 5 parts per million in some cases.

In 1970, the Blue Crab harvests were 200,000 pounds. The commercial crab industry has not harvested in the area since the warning. This is a great economic loss to the area. There also is a concern that the weekend fisherman may not be aware of the problem, especially if he is from out of town.


WARNING!
No harvesting of crabs or finfish.
MERCURY CONTAMINATED

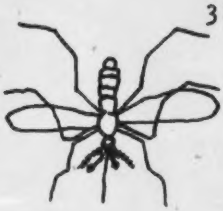
"SUPER--PRESERVATIVE" FOR SALE ??

You are a scientist who has discovered a new chemical. Any living thing sprayed with this chemical will not decay when it dies. Even animals that eat the treated organisms will not decay when they die. The chemical stops decomposers from growing. It is harmless in all other ways.

The leaders of several large countries want to know if they should add this chemical to their foods. It could increase their food supply but 20 percent since that much is normally lost to decay. Also, billions of dollars are lost as a result of decayed food which could be spent helping the needy. They are even thinking of spraying all farmlands in their countries. They are offering you several billion dollars for the chemical. Would you sell them the chemical? What advice would you give the leaders?

Write your decision and the advice you would give concerning your "super-preservative" below.

IT'S YOUR DECISION



You are a city health officer. You have been receiving complaints about the large number of mosquitoes on the beach. People are afraid that they may be disease-carrying again. Several years ago there was an outbreak of encephalitis carried by the mosquitoes.

You know the mosquitoes are hatching in some of the pools in the salt marsh.

As you see it, your options to control the mosquitoes are:

(1) to spray with DDT

(2) to spray with another insecticide

(3) fill in the pools where they are hatching

(4) put oil on the water where they hatch so the larva will have no oxygen and die

(5) add dragonflies to eat the mosquitoes

(6) do nothing, let people buy their own insect repellents

Write your choice and defend it in the space below:

TOPIC NINE--SUM IT UP

PLAN FOR THE FUTURE

Plan--

A mariculture system for the future.

Complete--

The P.S. Activity.

A MARICULTURE SYSTEM OF THE FUTURE

The earth is facing a food shortage for many reasons. The main reason is the increase in the population. Also, the growth of the cities is removing farmland from use. There is an increase in the demand for sea food. However, most of our own fishery resources are already being harvested to the greatest extent possible.

We are beginning to turn to farming of the sea or mariculture--growing of marine plants and animals. In some countries it is already established.

You are to design a plan for farming the ocean. Think about how you would design an aquaculture system.

Remember -- the design which works the best will be like a natural ecosystem and will not upset the balance or the cycles. Also the design which works the best will be used by others, with more recognition and rewards for you.

Things to consider in your design.

Location -- on land, in bays, or estuaries, in water off-shore, or out in the open ocean   etc.

Which organisms to grow and the number -- one, several or many

Light, water temperature, salinity, tides, currents, location of nutrients

Food chains, webs and pyramids

The material cycles

How to harvest and restock organisms

Draw--your plans. Give explanations for your selection.

P.S.

As you look back over what you have learned about the marine environment and the material cycles, what do you think?

Maybe the following incomplete sentences will help you organize your thoughts. (You may use more or less space than provided.)

I learned that I ____

____.

I learned that the marine environment ______________________

____.

I urge ______________________ to ______________________.

Who ____?

What can be done to ____________________________________

____?

I would like to ____

____.

I will ____.

I ____

etc. ____

____.